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16. Abstract

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National Transportation Safety Board
Washington, D.C. 20594
Safety Recommendation

Date: July 10, 1998

In reply refer to: A-98-44 through -58

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On August 7, 1997, at 1236 eastern daylight time,[1] a Douglas[2] DC-8-61, N27UA, operated by Fine Airlines Inc. (Fine Air) as flight 101, crashed after takeoff from runway 27R at Miami International Airport (MIA) in Miami, Florida. The three flightcrew members and one security guard on board were killed, and a motorist was killed on the ground. The airplane was destroyed by impact and a postcrash fire. The cargo flight, with a scheduled destination of Santo Domingo, Dominican Republic, was conducted on an instrument flight rules flight plan and operated under Title 14 Code of Federal Regulations (CFR) Part 121 as a Supplemental air carrier.

The National Transportation Safety Board determines that the probable cause of the accident, which resulted from the airplane being misloaded to produce a more aft center of gravity and a correspondingly incorrect stabilizer trim setting that precipitated an extreme pitch-up at rotation, was (1) the failure of Fine Air to exercise operational control over the cargo loading process; and (2) the failure of Aeromar to load the airplane as specified by Fine Air. Contributing to the accident was the failure of the Federal Aviation Administration (FAA) to adequately monitor Fine Air's operational control responsibilities for cargo loading and the failure of the FAA to ensure that known cargo-related deficiencies were corrected at Fine Air.[3]

Accident Scenario

The airplane departed controlled flight shortly after rotation, following an apparently normal taxi and takeoff roll. The Safety Board's correlation of data from the flight data recorder (FDR) and cockpit voice recorder (CVR) determined that the stick shaker warning activated

[1] Unless otherwise indicated, all times are eastern daylight time, based on a 24-hour clock.

[2] Boeing Commercial Airplane Group acquired the holdings of the Douglas Aircraft Company and McDonnell Douglas in 1997.

[3] National Transportation Safety Board. 1998. *Uncontrolled Impact With Terrain, Fine Airlines Flight 101, Douglas DC-8-61, N27UA, Miami, Florida, August 7, 1997.* Aircraft Accident Report NTSB/AAR-98/02. Washington, DC.

when the airplane was at an altitude of about 100 feet msl. According to the Board's performance study of the airplane's motion during the accident sequence, about 16 seconds after the start of rotation, at an altitude of about 300 feet msl, the airplane reached an extremely nose-high pitch attitude in the range of 30° and an angle-of-attack (AOA) approaching 20°, which resulted in an aerodynamic stall (an AOA of 15° was sufficient to bring the airplane into the stall region). Subsequently, the AOA decreased toward 10°, and the pitch decreased to below 20°, resulting in a brief recovery from the stall, followed by another AOA increase into the stall region 5 seconds later (the stall warning stopped at 12:36:12 and resumed at 12:36:17).

The ground scars and the airplane damage indicated that at impact, the pitch angle was about 23°, while the flight path angle was about 26° down. This resulted in an AOA of at least 49° at the time of impact, consistent with the airplane being in a deep stall. A continued stall is also consistent with the stick shaker stall warning and engine surge sounds recorded on the CVR in the final moments of the flight and the witness statements about pitch attitude during flight and at ground impact. The performance study showed that once the initial stall was reached, full recovery was unlikely because of the airplane's low altitude and the airplane's rapidly decreasing performance. Thus, based on analysis of FDR, CVR, and postaccident airplane performance data and on witness statements, the Safety Board concludes that the airplane pitched up quickly into a stall, that it recovered briefly from the stall, that it stalled again, and that recovery before ground impact was unlikely once the stall series began.

Airplane Handling Characteristics

The weight and balance form provided to the flightcrew showed a calculated center of gravity (CG) location at 30.0 percent mean aerodynamic cord (MAC). However, the Safety Board and the Douglas Products Division calculated a CG of 32.8 percent MAC based on a loading scenario developed from information provided by Aeromar loaders, Fine Air flight follower testimony, pallet weight documentation, and postaccident communication with Aeromar representatives. The Safety Board also notes that a relatively small addition to and/or redistribution of cargo could have moved the airplane's CG beyond the aft limit of 33.1 percent MAC.

The succession of errors made by Fine Air and Aeromar in loading this flight and the deficiencies in the Aeromar and Fine Air loading procedures identified during postaccident FAA inspections made it impossible to precisely determine the weight and CG from the data that were available following the accident. For example, the cargo destined for the accident airplane was listed as weighing 89,719 pounds when it arrived at Aeromar's warehouse in big pacs and boxes. After being put on pallets and secured with plastic covers and netting, the cargo was listed on the Aeromar pallet load sheet as weighing 88,923 pounds, or 796 pounds less than the cargo weighed at arrival. Pallets and netting added an additional 275 pounds per pallet (or about 4,400 pounds to the total cargo weight). Based on postaccident Aeromar statements that the entire cargo delivered to Aeromar was loaded onto pallets for shipment on the accident airplane, the actual cargo weight could have been at least 94,119 pounds. Thus, the weight of the cargo that Aeromar provided to Fine Air could have been 5,196 pounds more than listed on the pallet weight form (which resulted in the CG of 32.8 percent MAC). This additional weight could have had a significant effect on the CG of the airplane, depending on how it was distributed through the cabin.[4]

In February 1998, the Safety Board conducted a series of tests using a DC-8 full motion flight training simulator. Multiple takeoff attempts were simulated using aircraft weight, flap settings, and thrust values equivalent to the accident conditions and a range of CG values. The simulator flight tests suggest that at 33 percent MAC, the column inputs recorded on the accident airplane's FDR might have been sufficient to prevent the pitch-up and stall. Further, at 35 percent MAC, the simulator reached the stall condition more quickly than did the accident airplane. Although adequate control power existed from the elevators and pitch trim to recover the airplane at 35 percent MAC, successful recovery required an immediate and aggressive control input response (full forward column, which could be assisted by nose-down trim). Pilots involved in the simulation reported that their immediate control inputs were successful for the conditions tested because they were anticipating the pitch-up at rotation.[5] At CG values aft of 35 percent, the airplane was increasingly subject to autorotation tendencies well before rotation speed and to tail strike on the runway, which did not occur during the accident. However, based on the loading information and the simulator tests, the Safety Board concludes that the CG of the accident airplane was near or even aft of the airplane's aft CG limit.

Statements by the flightcrew on the CVR show that the stabilizer trim was set during taxi-out at 2.4 units ANU, the value appropriate for the trim setting and CG of 30 percent MAC that the flightcrew had been given. The number of trim-in-motion tones recorded on the CVR during the recovery attempt and the full-nose-down trim setting found at impact were also consistent with the flightcrew having set 2.4 units during taxi.

The Safety Board considered the effects of different aircraft loadings on CG location and the associated pitch trim settings. The investigation found that 13 pallets had been moved farther aft than indicated on the loading sheet. At 88,923 pounds total cargo weight, moving the 13 pallets aft (and turning pallet four 90°) would have shifted the CG from 24.0 percent MAC (requiring 5.4 units airplane nose up [ANU] pitch trim) to 32.4 percent MAC (1.0 units ANU). Further, if the cargo weight were 94,119 pounds, the CG would have shifted from 24.0 percent MAC (5.4 units ANU) to 32.8 percent MAC (0.9 units ANU). Thus, pushing the 13 pallets aft shifted the CG farther aft by at least 8 percent MAC. Further, because the accident airplane's stabilizer trim setting was 2.4 units ANU, the Safety Board concludes that the CG shift resulted in the airplane's trim being mis-set by at least 1.5 units ANU (2.4 minus 0.9 units at 94,119 pounds).

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[4] Based on a payload weight of 94,119 pounds, the Safety Board calculated that the redistribution of 250 pounds from the front to the rear of the airplane could have resulted in a CG of 33.2 percent MAC. Redistribution of 1,200 pounds from the front to the rear could have resulted in a CG of 35 percent MAC.

[5] In its investigation of a 1993 accident involving a United Airlines DC-8-54F in Detroit, the Safety Board found that "recovery of the airplane at rotation was possible if immediate nose-down trim was applied along with full forward elevator input." However, the Safety Board concluded that "once the airplane left the ground and started to accelerate, recovery was improbable." (See National Transportation Safety Board. 1983. *United Airlines Flight 2885, N8053U, Douglas DC-8-54F, Detroit, Michigan, January 11, 1983.* Aircraft Accident Report NTSB/AAR-83/07. Washington, DC.)

Such a mistrim would cause a greater than expected nose-up pitching moment. This would be exacerbated by the lighter control column forces that result from an aft CG location. Consequently, the Safety Board concludes that the aft CG location and mistrimmed stabilizer presented the flightcrew with a pitch control problem; however, because the actual CG location could not be determined, the severity of the control problem could not be determined.

The simulator flight tests could not replicate the accident flight precisely because of limitations inherent in the simulator; for example, the aerodynamic data upon which the simulator's performance was based may not accurately model the actual airplane's performance in ground effect (during rotation and initial climb) or when high-pitch rates are present near stall. Further, the simulator's performance characteristics become invalid in the stall region. Timing of the control column movements in the simulated takeoff attempts was also a factor. Evaluation of the simulator data showed that small differences in the timing of inputs produced dramatically different results 5 to 10 seconds later.

Unfortunately, it was also not possible to replicate precisely the flightcrew's control inputs because, due to insufficient documentation, the control column position (CCP) positions recorded by the accident airplane's FDR could not be converted into precise position values but rather represented relative motion. The Safety Board could not determine with certainty the correlation between the CCPs recorded by the FDR and actual positions of the control column on the airplane. Thus, the simulator tests did not permit the Safety Board to determine precisely the response of the accident airplane to the flightcrew's control inputs.

Flightcrew Actions

Statements recorded on the CVR indicated that the flightcrew recognized a problem with airplane handling about the pitch axis immediately as the airplane rotated. At 12:35:51.5, 1.6 seconds after the "rotate" call out and about 1 second after the first officer began to move the control column aft, the captain began his "easy easy easy easy" remark. Based on FDR data, it appears that the captain made his statement before the airplane's pitch attitude had rotated significantly nose-up. The CCP moved aft a total of about 5°. About 2 seconds later (at 12:35:53.5), still during rotation, the FDR showed forward movement of the control column. The magnitude of the forward movement was about 4° from its most aft position; however, about 2 seconds after the start of the forward motion it was moved aft again. At 12:35:57 the control column was moved forward, and it reached its most forward position (presumed to be the full forward limit of the control column) at 12:36:01.

The first officer's continued aft column input for 2 seconds after the captain began his "easy easy easy easy" remark exacerbated the pitch-up that was developing from the mistrimmed stabilizer. However, the first officer's 2-second response time in responding to the captain was understandable in light of the physiological, neurological, and cognitive contributors to reaction time. Further, is not clear that the flightcrew would have recognized the need for abrupt, aggressive, and sustained action at the initiation of the pitch-up.

Regarding the first officer's subsequent aft control column input (at 12:35:54.5), the Safety Board notes that flightcrews are trained to avoid rapid and excessive control inputs and to gauge the results of control inputs before making additional corrections. In moving the control column forward and aft, the first officer might have been attempting to judge what nose-down control column inputs were required to correct the airplane's developing pitch-up attitude. The Safety Board also notes that the application of immediate and forceful nose-down control inputs at rotation is counter-intuitive and contrary to the training and experience of line flightcrews.

According to the CVR, the first trim-in-motion sound occurred a fraction of a second before the first aural stall warning (at 12:36:02), indicating that the trim inputs were not initiated until the accident airplane was already very close to a stall. Although aggressive nose-down trim inputs were made thereafter and until the trim reached its full nose-down position, about a 5-second delay occurred between the flightcrew's first attempt to control the pitch-up with nose-down column inputs and the first inputs of nose-down trim.

If the first officer had chosen to trim the airplane in the first, critical moments during and after rotation, he would have obtained a greater nose-down pitching moment and might have been able to correct most, or all, of the mistrim condition, preventing the airplane from stalling. The Safety Board considered the possibility that a more experienced pilot, particularly one who had previously encountered an aft-loaded, out-of-trim condition on takeoff, might have assessed the situation more rapidly and engaged the airplane's powerful pitch trim more quickly to aid in the recovery attempt. For example, if the captain had been flying the takeoff, he might have more quickly recognized the need for and applied a trim correction.

Although the Safety Board was unable to determine precisely how far aft the CG was located and thus the extent to which the airplane was mistrimmed, the Safety Board concludes that the mistrim of the airplane (based on the incorrectly loaded cargo) presented the flightcrew with a situation that, without prior training or experience, required exceptional skills and reactions that cannot be expected of a typical line pilot. Although the unanticipated nature of the rapid pitch-up was an important aspect of the situation, the Safety Board concludes that training for flightcrews in dealing with misloading, miscalculated CG, and mistrimmed stabilizers would improve the chances for recovery from such situations. However, there is no current FAA requirement for air carriers to provide flightcrews with training in identifying and responding to a rapid-pitch-up during rotation from a mistrimmed stabilizer. Therefore, the Safety Board believes that the FAA should require all 14 CFR Part 121 air carriers to provide flightcrews with instruction on mistrim cues that might be available during taxi and initial rotation, and require air carriers using full flight simulators in their training programs to provide flightcrews with Special Purpose Operational Training that includes an unanticipated pitch mistrim condition encountered on takeoff.

Cargo Document Preparation, Communications, and Ramp Delivery Procedures

In the hours before the accident flight, the exchange of airplanes required a series of significant cargo paperwork changes by Fine Air flight followers and Aeromar employees. Fine Air flight followers determined that the cargo weight would be 87,923 pounds and that the CG and trim would be 30 percent MAC and 2.4 units ANU if the airplane was loaded as directed.

Fine Air flight followers refined the weight and balance calculations for N30UA, the originally assigned airplane, to accommodate weight limitations for N27UA and then defined the pallet sequence to produce a more aft CG of 30 percent MAC (moving the pallet in position 13 to position 17 and leaving position 13 vacant). Fine Air flight followers stated that these changes were communicated to Aeromar by fax and by direct telephone conversations. However, the fax communications were the subject of conflicting statements by personnel from both companies. Further, there was no evidence that the revised paperwork was picked up by the Aeromar security guard responsible for the accident flight's cargo.

Although the Fine Air flight follower told Aeromar to reduce the weight of pallet "G" by 1,000 pounds (reducing the total cargo weight to 87,923 pounds) because of the landing weight restrictions for N27UA, that weight was not removed by Aeromar. Therefore, the final load sheet provided to the flightcrew was in error by an additional 1,000 pounds. The mistake was missed by Aeromar and Fine Air. The Fine Air flight follower also improperly recorded the pallet weight in position 17 as 5,860 pounds on the final load sheet, rather than 5,960 pounds as recorded by Aeromar on the pallet loading form.

The Safety Board's investigation also revealed errors in the printed load sheet form. The form indicated that it was for a DC-8-61 airplane, but one part of the form that affected the CG calculation (the fuel distribution scale) was based on data for DC-8-62 and -63 airplanes. The printed Fine Air load sheet form also incorrectly listed the maximum weight allowable for pallet position 18 as 6,088 pounds, instead of the correct weight of 3,780 pounds, which resulted in pallet position 18 exceeding its weight limitation by 1,247 pounds on the accident flight. Calculations based on this form resulted in a computed CG that was farther aft than the actual CG. The proper loading form would have yielded a 26.5 percent MAC CG for 87,923 pounds rather than 30 percent MAC. The built-in CG errors could have accounted for reported flightcrew requests to Fine Air flight followers to provide more rearward CGs to improve the flying characteristics of their airplanes. However, moving the CG aft would not correct the mistrim but would lighten control forces somewhat.

Weight and balance errors were a persistent problem at Fine Air previously identified by two Department of Defense (DoD) inspections (in 1994 and 1996 respectively) and two FAA inspections (a preaccident national aviation safety inspection program [NASIP] inspection and a postaccident regional aviation safety inspection program [RASIP] inspection). Shortly after the 1996 DoD inspection, Fine Air proposed redesigning its load sheet "as an interim measure until they automate weight and balance computations." However, this redesign was not accomplished before the accident and would likely not have revealed the fuel loading and pallet weight errors in the load sheet. Further, the Safety Board found during its investigation that Fine Air's load sheet, revised after the accident, also contained errors and discrepancies when compared to Douglas data, and that Fine Air's stabilizer trim setting data sheet also contained errors. The Safety Board notes with disappointment that Fine Air revised the load sheet form incorrectly after errors were found after the accident, and that FAA principal inspectors assigned to Fine Air failed to detect this mistake. Based on an examination of Fine Air and Aeromar loading documents and statements from Fine Air and Aeromar employees, the Safety Board concludes that procedures used by Fine Air and Aeromar to prepare and distribute cargo weight pallet distribution forms and final weight and balance load sheets were inadequate to ensure that these documents correctly reflected the true loading of the accident airplane. The Safety Board is concerned that similar problems may exist at other carriers. Therefore, the Safety Board believes that the FAA should conduct an audit of all CFR Part 121 supplemental cargo operators to ensure that proper weight and balance documents are being used, that the forms are based on manufacturer's data or other approved data applicable to the airplane being operated, and that FAA principal inspectors confirm that the data are entered correctly on the forms.

There was conflicting information about whether the Aeromar and Fine Air employees involved in the loading operation were aware of the airplane change and of the changes in the loading instructions for the accident airplane. Aeromar's vice president stated that a company security guard picks up loading paperwork at Fine Air "immediately prior to the loading of a plane" or when the security guard delivers the cargo to the Fine Air ramp. The Fine Air flight follower who calculated the original load for N30UA stated that the Aeromar security guard in charge of the cargo picked up the paperwork with the cargo before 0600 on the day of the accident. However, the flight follower who went on duty after 0600 stated that the security guard did not return to pick up the revised weight distribution form. Although Fine Air flight followers stated that they faxed updated weight distribution and loading information to Aeromar before the flight, Aeromar's vice president stated that such a practice was "neither customary or usual." Based on interviews with Aeromar employees, the security guard assigned to the flight's cargo would have already been on duty at the Fine Air ramp when Fine Air flight followers said that they faxed the load changes to Aeromar. Testimony by Aeromar loaders indicated that cargo pallets were arranged on the ramp for loading according to the weight distribution form calculated for N30UA. Therefore, the Safety Board concludes that the security guard was not aware of the airplane change, and that he instructed Aeromar loaders to load the airplane in accordance with the weight distribution form he possessed for N30UA.

Airplane Loading Operations

Although there were conflicting statements about several aspects of the loading process, Aeromar cargo handlers' descriptions of the initial loading were consistent with the planned weight and balance configuration for N30UA, with pallet positions 2 and 17 initially left vacant. However, Aeromar cargo handlers stated that pallets could not be secured with locks during the initial loading. A subsequent check by the Aeromar supervisor determined that pallet locks would not latch in the rear of the airplane because pallet edges were not positioned properly, preventing locks from engaging on each edge of adjacent pallets.[6] According to the statements of the loaders and supervisor, in an attempt to correct this, all pallets from position 5 aft were pushed back one position each, which resulted in pallet position 17 being filled and position 5 being emptied. Pallet 4 was turned 90° and pushed back, which resulted in the pallet occupying all of position 5 and part of position 4.[7] According to loader statements, pallet 3 was secured by

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[6] The Aeromar loading supervisor said the locks would not latch because cargo extended over the sides of the pallets. Because of conflicting testimony, it could not be determined who first identified the problem with the loading and who issued instructions to rearrange the load.

[7] These actions were initiated by the loading crew or its supervisors and did not adhere to any planned loading configuration for the cargo on this airplane, which was calculated in Fine Air operations by the Fine Air flight follower.

locks on the front and back sides, which would have left position 2, by the cargo door, empty, with position 1 (with locks up) by the forward (cockpit) bulkhead. Thus, based on loader statements about how the airplane was first loaded and subsequent changes to the cargo's configuration, the Safety Board concludes that the accident airplane (N27UA) was initially loaded according to Fine Air's load distribution for N30UA; further, the final load configuration did not match the planned load for either airplane.

Loaders gave contradictory statements about the number of pallet engaged locks from positions 6 through 18 when the rearrangement and loading was completed. The Aeromar loading supervisor, who was responsible for ensuring that pallet locks were in place, stated that he put up several locks near position 18, and that he relied on other loaders to put locks up forward of that position. However, the Safety Board found considerable evidence indicating that few of the pallet locks were engaged. For example, 57 of the 60 locks recovered from the wreckage (from a total of 85 installed) were found in the unlocked position, and postaccident testing found no evidence of cracking, shearing, or elongation associated with impact damage and failure. Although it was the Aeromar loading supervisor's responsibility (according to his job description) to ensure that the locks were in place, he did not verify that they had been latched, relying instead on the thoroughness of loaders working in what was described as a hot, cramped, and stifling environment.[8]

Moreover, the Fine Air supervisor, who was the forklift driver (and, according to all parties involved, was not acting in a supervisory capacity) for the loading of the accident airplane, stated that when he was in charge of loading operations he always checked to make certain that the locks were up around pallet position 1. He said that he did so because these locks were readily visible to the flight engineer, who otherwise might insist on a reload if locks were down or missing. This implies that he believed it was less important to engage the locks that were not visible to the flight engineer, and suggests a casual attitude about the importance of aircraft weight and balance.

Cargo loading requires the coordination of a team under the direction of a supervisor to accomplish a multistep process, including identifying the appropriate pallet, loading the pallet onto the airplane, positioning the pallet inside the airplane, and securing the pallet in position. These basic steps were not followed during the loading of the accident flight. When it became evident to the loading crew that the cargo would not secure properly, decisions were made about pallet positioning and load security that suggested a desire to complete the job quickly. Little or no attempt was made to determine whether these changes would adversely affect the airplane in flight. Therefore, the Safety Board concludes that the Aeromar cargo loading supervisor failed to ensure that the pallets were loaded according to an approved load plan (in this case neither load plan was followed) and failed to confirm that the cargo was properly restrained.

Because there were vacant spaces in the cargo distribution and the cargo was not properly secured, the Safety Board considered whether shifting cargo at rotation could have contributed to the accident. Unsecured cargo pallets could shift during acceleration, and more significantly

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[8] For example, loaders said the temperature inside of the airplane was "just like an oven." However, it could not be determined to what extent, if any, these conditions contributed to the misloading of the airplane.

during rotation, if there were empty pallet positions between unsecured pallets. However, when Aeromar loaders pushed all of the cargo pallets from position 5 rearward one position and turned pallet 4 sideways into position 5, this created a line of contiguous pallets from position 5 to position 18, the aft-most cargo pallet position in the airplane. This suggests that the misloaded, aft-heavy condition existed at the time of rotation and was not caused by cargo shifting as the airplane's deck angle increased. However, based on loader statements that cargo extended over the sides of some pallets (which prevented the locks from being engaged), some shifting of cargo and additional compression might have occurred as the airplane's deck angle increased. The Safety Board concludes that a significant shift of cargo rearward at or before rotation did not occur and was not the cause of the initial extreme pitch-up at rotation; although, cargo compression or shifting might have exacerbated the pitch-up moment as the pitch increased.

Following the accident, the FAA's RASIP inspection team found numerous problems related to Fine Air's loading operations, including improperly secured and broken pallets, frayed and broken netting, and deficiencies in the areas of weight and balance control, cargo weighing, and security. These areas were also addressed in a consent agreement Fine Air signed with the FAA in September 1997, in which the operator agreed to revise its cargo handling system and procedures, including its "maintenance program for cargo pallets and cargo restraint devices, cargo pallet loading procedures, cargo weighing procedures...aircraft loading procedures [and] aircraft weight and balance procedures."

As part of its revised procedures, Fine Air developed a loading supervisor certification form that loading supervisors must sign to indicate that the load was placed on the airplane according to plan and restrained properly. In addition, the revised Flight Operations Manual (FOM) breaks down the loading process into specific procedures and steps to be followed by the loading supervisor when loading the airplane,[9] which helps to standardize the loading process.

However, the load certification form only contains an overall statement attesting to the fact that loading was performed in accordance with Fine Air's loading requirements. Cargo loading supervisors and cargo handlers work under difficult conditions that can include physical strain, time pressure, extreme temperatures, and nighttime hours, all of which can affect job performance. Thus, the Safety Board concludes that the difficult work environment of cargo loaders has the potential to cause loading errors if the loading process is not adequately structured to compensate for the detrimental environmental effects on human performance. However, these conditions can be mitigated by developing independent controls to ensure that critical steps in the loading process are completed properly. Therefore, the Safety Board believes that the FAA should require carriers operating under 14 CFR Part 121 to develop and use loading checklists to positively verify that all loading steps have been accomplished for each loaded position on the airplane and that the condition, weight, and sequencing of each pallet is correct.

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[9] In addition to the loading supervisor certification form, Fine Air made significant revisions to its FOM, AOM, and other documents outlining new load planning procedures, loader and supervisor responsibilities, and flightcrew responsibilities after resuming operations in October 1997 under the consent agreement. The airline stated that it now has provisions in place to ensure that pallets are built properly, that weights are verified (e.g., pallets are now weighed by Fine Air before being loaded), and that loading operations are thoroughly supervised.

Operational Control

Fine Air's wet lease agreement with Aeromar called for Aeromar to provide "fuel, loading and unloading at all stops," but stipulated that Fine Air retained operational control of all flights, and that all servicing was to be done under the supervision of Fine Air employees. Fine Air's operational control responsibilities were also defined in the company's FOM and spelled out in an addendum to Fine Air's lease agreement with Aeromar. Although 14 CFR Part 121.537 outlines supplemental air carrier operational control responsibilities, the principal operations inspector (POI) assigned to Fine Air stated that operational control for loading was not specifically addressed in the regulations. Further, the Safety Board could identify no such requirement in these regulations. However, the FAA stated in an October 1997 letter to Fine Air that under provisions of Part 121, "no aspect of operational control can be negotiated away...[including] loading of cargo as it relates to weight and balance requirements, cargo restraint requirements and hazardous materials requirements."

Although the terms of the wet lease agreement (later determined by the FAA to be a "transportation" or "charter" agreement) stated that Fine Air retained operational control, Fine Air managers stated that before the accident the company did not supervise loading operations carried out by Aeromar. In addition, Fine Air did not weigh palletized cargo delivered by Aeromar or have other procedures in place to verify cargo weights and the accuracy of the load form provided to the crew by Fine Air flight following. The Safety Board concludes that Fine Air failed to exercise adequate operational control of loading operations conducted by Aeromar on the accident flight as required by Part 121, the operational control terms of its lease agreement with Aeromar, and its own operating policy. Further, the Safety Board concludes that Fine Air's failure to exercise adequate operational control was causal to the accident by creating an operational environment in which cargo was loaded into Fine Air airplanes without verification of pallet weights and proper load distribution and by fostering a management philosophy that allowed airplanes to be dispatched without verification and control procedures in place to ensure that load-related, flight safety-critical tasks had been accomplished.

Loader Experience and Training

Four of the Aeromar cargo handlers had previous experience in air cargo operations in Miami. However, one cargo handler and the Aeromar loading supervisor had no experience in air cargo operations before employment with Aeromar. The Aeromar loading supervisor was hired about 3½ months before the accident and had been promoted to supervisor about 2 weeks before the accident on the basis of his performance. All cargo loading personnel interviewed by Safety Board investigators accurately described how to engage and disengage cargo locks and demonstrated a general knowledge of proper cargo loading procedures.

Air carriers are currently not required to provide initial classroom training or recurrent training for personnel involved in cargo handling. Training for loading personnel at Aeromar and Fine Air was described as on-the-job training. Aeromar cargo handlers stated that they did not receive any classroom training and that their supervisor had provided verbal instructions and information about the job of loading an airplane when they first were assigned to the cargo ramp. Aeromar cargo handlers who had previously worked at Fine Air indicated that while at Fine Air they received no classroom training. The Fine Air loading supervisor also stated that he had received no classroom training for cargo loading. Although it appears that on-the-job training was an effective method of instruction for the basic technical job requirements, the misloading of the accident airplane indicates that loaders did not recognize the importance of loading an airplane consistent with the calculated weight and balance plan, or the importance of properly restraining the cargo. Therefore, the Safety Board concludes the loaders who loaded the accident airplane were not aware of the potentially catastrophic consequences of misloading the airplane and the failing to properly secure cargo, and that this contributed to the accident.

It is the Safety Board's understanding that cargo handler positions are typically entry-level positions characterized by relatively high rates of turnover. The Safety Board is concerned that because of a high turnover rate it can be difficult to control the quality of instruction delivered through on-the-job training. Because it is critical to the safety of flight to ensure that cargo has been loaded according to plan and properly restrained, all individuals associated with the loading process must be provided with consistent and comprehensive training in airplane loading.

After the accident, the FAA issued air transportation bulletin Handbook Bulletin for Airworthiness and Air Transportation (HBAT) 97-12 to FAA Order 8400.10 "Air Transportation Operations Inspector's Handbook."[10] In this bulletin the FAA states the following:

> Currently, part 121, section 121.400 prescribes the requirements applicable to each certificate holder for establishing and maintaining a training program for crewmembers, aircraft dispatchers, and other operations personnel. While the term "other operations personnel" is not currently defined in this subpart, it is evident that employees of a certificate holder who have the duty to supervise the loading of an aircraft or who qualify and authorize other persons to perform this function, must be trained on the certificate holder's procedures.

The bulletin encouraged principal inspectors to review any training program operators had for their cargo loading supervisors.

In the consent agreement issued after the accident, the FAA required Fine Air to "review and revise as necessary a training program for cargo handlers and other personnel responsible for cargo handling and aircraft loading." In response, Fine Air created a training program for cargo loader supervisors and cargo handlers[11] that included approximately 7 hours of training including curriculum areas covering the following:

- basic aerodynamics
- weight and balance for ground handlers

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[10] The bulletin was issued on September 5, 1997, as a Joint Flight Standards Handbook Bulletin; therefore, it was also added to FAA Order 8300.10, "Airworthiness Inspector's Handbook" as HBAW 97-12.

[11] Fine Air's training manual states that "This category of training is for an employee whose job description includes the identification of, positioning, direct and indirect handling of cargo to be loaded on FINE AIR aircraft to ensure the proper loading and handling of cargo aboard company aircraft." In addition to initial training there are provisions for recurrent training in this program.

- safe handling of aircraft cargo
- pallet building, loading, and unloading.

The Safety Board considers the steps taken by Fine Air to provide formal training to its cargo handling personnel to be a significant improvement in its training program because the curriculum is standardized and training modules go beyond the technical requirements of the job. However, the Safety Board recognizes that the consent agreement was directed only to Fine Air and is concerned that the training programs of other operators may suffer from similar deficiencies. Further, HBAT 97-12 only encouraged inspectors to examine operators' training for supervisory cargo loading personnel, and inspectors do not have the appropriate guidance material to evaluate training programs in cargo handling operations.[12] Thus, the Safety Board concludes that formal training is necessary to ensure that cargo handling personnel receive standardized instruction on safety-critical aspects of the loading process.[13] Therefore, the Safety Board believes that the FAA should require training for cargo handling personnel and develop advisory material for carriers operating under 14 CFR Part 121 and POIs that addresses curriculum content that includes but is not limited to, weight and balance, cargo handling, cargo restraint, and hazards of misloading and require all operators to provide initial and recurrent training for cargo handling personnel consistent with this guidance.

Flightcrew Load Verification Responsibilities

According to the Fine Air Aircraft Operation Manual (AOM) used at the time of the accident, the flight engineer was required to verify that at least three cargo pallet locks were locked at each position loaded with a pallet during his preflight check in Miami. However, Fine Air representatives told Safety Board investigators that it would have been "unlikely" for a flight engineer to make this check of the entire airplane during routine operations in Miami.[14] Other company personnel indicated that in Miami airplanes were typically loaded before flightcrews arrived and some loads did not provide sufficient clearance for the flight engineer to verify the status of the locks in positions aft of the cargo door.[15] The Safety Board recognizes that Fine Air changed the flight engineer's preflight checklist after the accident as part of a review and revision of its loading procedures and that new controls are now in place to ensure that the locks are

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[12] FAA Order 8400.10 does not provide guidance on evaluating training programs for cargo loading operations. In contrast, FAA Order 8400.10 and advisory circular (AC) 120-60 provide guidance material for FAA inspectors reviewing the initial and recurrent training programs that air carriers establish as part of their ground deicing and anti-icing programs under 14 CFR 121.629.

[13] At least one industry trade union, the International Association of Machinists and Aerospace Workers, stated that it offers training to ramp workers and other aviation personnel on the impact on flight safety of routine duties such as cargo loading, hazardous materials handling, and deicing operations.

[14] According to Fine Air's FOM, it is the joint responsibility of the first officer and the flight engineer to ensure proper airplane loading at outstations.

[15] Pallets are typically configured so that there is access to the area around the cargo door, to verify that door has been secured. Therefore, it is likely that the flight engineer was able to verify locks were up on positions 1 and 3 in the accident airplane. Loaders told Safety Board investigators that if these locks were not locked and visible to the flightcrew they risked being asked to reload. The current Flight Engineer's Preflight expanded checklist (page 6-12-19, issued 9/26/97, revision 35) only requires a check that all pallet locks installed in the airplane be operable. It no longer requires the engineer to ensure that a minimum of three pallet locks per position be used and locked.

engaged. However, at the time of the accident the flight engineer faced inconsistent guidance and expectations about this task. Thus, the Safety Board concludes that although the flight engineer was required to ensure that all cargo pallet locks were locked, company operating procedures and practices in MIA hindered him from accomplishing this task. Further, the Safety Board is concerned that such differences between flightcrew requirements for loading oversight and actual operational procedures may exist at other air carriers. Therefore, the Safety Board believes that the FAA should review the cargo loading procedures of carriers operating under 14 CFR Part 121 to ensure that flightcrew requirements for loading oversight are consistent with the loading procedures in use.

Although they possessed the airplane's load sheet (based on numbers provided by Fine Air flight followers) and the flight engineer was required to conduct a visual inspection, the accident flightcrew had no practical way to verify the airplane's weight and balance and gross weight before takeoff. However, the Safety Board notes that an electronic system has been in widespread use for years in both cargo and passenger operations that provides flightcrews with a digital readout in the cockpit of weight and balance and gross weight values. The STAN (Sum Total Aft and Nose) system uses pressure transducers to convert main gear and nose gear shock strut air pressure to an electronic signal. The cockpit readout, on the flight engineer's instrument panel, provides the flightcrew with an independent, direct measure of the airplane's gross weight and CG. Cockpit instrumentation showing these values would have added a critical last-minute safeguard for this flightcrew. Thus, the Safety Board concludes that if the flightcrew had had an independent method for verifying the accident airplane's actual weight and balance and gross weight in the cockpit, it might have alerted them to the loading anomalies, and might have prevented the accident. Therefore, the Safety Board believes that the FAA should evaluate the benefit of the STAN and similar systems and require, if warranted, the installation of a system that displays airplane weight and balance and gross weight in the cockpit of transport-category cargo airplanes.

FAA Surveillance and Oversight

The FAA's RASIP inspection of Fine Air following the accident found anomalies that the inspection team's report characterized as "an indication of a systemic problem at Fine Airlines." Echoing findings in previous preaccident FAA and DoD inspections, the RASIP report stated that inspectors had found problems in the areas of weight and balance control, cargo weighing, the accuracy of pallet weights, the condition of pallets and netting, and the condition of airplane cargo compartments and equipment. All of these findings, the report concluded, had "an impact on the safety of flight."

FAA inspectors assigned to Fine Air and Miami Flight Standards District Office (FSDO) managers stated that before the Fine Air accident, there was "no guidance," or "minimal guidance," in FAA written directives for the surveillance of cargo operations, and that there were no guidelines on how to evaluate the condition of pallets, netting, and other cargo equipment. The principal maintenance inspector (PMI) assigned to Fine Air described his attitude to cargo inspection before the accident as "to us, cargo is cargo." However, the team leader of the postaccident RASIP inspection at Fine Air, who is a PMI assigned to the United Parcel Service certificate, stated that specific guidance should not have been needed to discover the problems the RASIP inspection team found relating to the condition of pallets, nets, and cargo deck flooring, noting that these problems were "evident." Moreover, during an en route inspection to Santo Domingo conducted a week before the accident, the Fine Air PMI was able to identify numerous loading problems, including damaged pallet netting, improper cargo loading, and a scale that was not in a location to weigh pallets. Although the PMI wrote a letter to Fine Air after the accident (on August 11, 1997) that asked Fine Air to amend its work cards for "C" checks in the areas identified as deficient during the en route inspection, no enforcement case was opened based on these findings, and the PMI did not take any other direct action to correct the immediate problem.

The manager of the FAA's Miami FSDO stated that he believed that the FAA surveillance of Fine Air's operations was "adequate" before the accident, but acknowledged that inspectors were "concentrating their emphasis on other areas," not on cargo loading. The FAA regional director, based in Atlanta, whose jurisdiction included the Miami FSDO, stated that "it's hard to define quality of surveillance," but acknowledged that the problems found in the RASIP should have been found earlier by the principal inspectors assigned to Fine Air.

Although the regional director noted that local inspectors can become bogged down in "certificate maintenance" (manual revisions, training program oversight, and other paperwork duties) at the expense of surveillance, even when they are aware of the findings of special inspections conducted by other teams, the director conceded that operations involving older airplanes, less experienced crews, and a "smaller [cost/profit] margin...are a concern." Nevertheless, cargo loading and weight and balance problems were repeatedly identified at Fine Air before and after the accident, and inspectors assigned to Fine Air had discovered and documented at least some of these problems before the accident. Therefore, the Safety Board concludes that the FAA inspectors assigned to Fine Air failed to ensure that known deficiencies in Fine Air's cargo operations were corrected. Thus, these problems went beyond a lack of broader FAA inspector guidance on inspecting cargo operations, and the FSDO manager conceded that senior FAA management had expressed "concern that we're not proactive."

Although the problems with the Miami FSDO's surveillance program at Fine Air pertained mostly to a failure to act on findings, the Safety Board is also concerned that the surveillance of cargo loading operations is not specifically required in the annual work programs established for FAA flight standards inspectors. The Safety Board concludes that the entire sequence of cargo loading operations, from preparation of the pallets/containers through the information provided to flightcrews, has a direct effect on flight safety and should not be neglected by the FAA surveillance program, particularly for the cargo air carriers operating under 14 CFR Part 121. Therefore, the Safety Board believes that the FAA should require all principal inspectors assigned to 14 CFR Part 121 cargo air carriers to observe, as part of their annual work program requirements, the complete loading operation including cargo weighing, weight and balance compliance, flight following, and dispatch of an airplane.

During its investigation of this accident, the Safety Board found numerous preaccident indicators of problems not only at Fine Air, but at other cargo Part 121 operators under the jurisdiction of the Miami FSDO. In the case of Fine Air, these included the findings of previous NASIP, RASIP, and DoD inspections at Fine Air. In another situation similar to Fine Air, Miami-based cargo operator Millon Air voluntarily ceased operations on October 24, 1996, following an FAA inspection conducted after a Millon Air Boeing 707 freighter crashed in Manta, Ecuador, two days earlier on October 22, 1996. (In its investigation of several previous accident and incidents involving Millon Air, the Safety Board had found a series of FDR-related maintenance deficiencies). In 1995, the FAA suspended the operating certificate of another Miami-based Part 121 cargo and passenger carrier, Arrow Air, after an inspection found evidence of serious safety violations. Thus, the Safety Board concludes that the Miami FSDO lacked clear management policies to ensure that sufficient and appropriate surveillance was conducted and that surveillance results were acted upon; further, the FSDO was not aggressive in its inspection and management of the Fine Air certificate and this contributed to the accident.

Such cases were not limited to the Miami FSDO. In the case of the May 11, 1996, accident in the Florida Everglades involving a ValuJet DC-9-32, FAA postaccident inspections found numerous maintenance and operational deficiencies that resulted in the air carrier ceasing operations when it entered into a consent agreement with the FAA in June 1996. Deficiencies in ValuJet's operations had been thoroughly documented in an FAA report prepared before the accident and in RASIP and NASIP inspections conducted before the accident. The February 14, 1996, report noted "some weakness in the FAA surveillance" of the airline and inattention to "critical surveillance activities." The report, which recommended that consideration be given to the "immediate recertification" of the airline, was not provided to the Atlanta FSDO or to ValuJet until after the accident. These maintenance and operations-related problems, which were identified by FAA regional management as requiring greater scrutiny and concern, should have been sufficient to alert the FAA's senior managers to the need for more aggressive surveillance and before the Fine Air accident. Since the accident, FAA officials have acknowledged that under current oversight programs what they described as system failures like Fine Air are difficult to detect, and that the existing system of surveillance was inadequate. Moreover, a recent GAO report on the effectiveness of FAA inspector surveillance concluded that many FAA inspections "are not thorough or structured enough to detect many violations," and that inspectors often do not initiate enforcement actions because "doing so entails too much paperwork." Based on these repeated problem indicators and the FAA's acknowledgement of the shortcomings of its current oversight system, the Safety Board concludes that the deficiencies found in the Miami FSDO's oversight of Fine Air and other carriers in its jurisdiction are indicative of a broader failure of the FAA to adequately monitor air carriers, especially supplemental cargo carriers, in which operational problems had been identified.

Based on its investigation of the ValuJet Everglades and the Fine Air accidents, the Safety Board is also concerned about the effectiveness of the NASIP and RASIP inspection processes. In the case of each airline, preaccident inspections identified operational and airworthiness deficiencies. Although the findings of these inspections resulted in short-term corrective actions for the specific items that were found to be deficient, the inspections failed to identify and address systemic problems that were found in postaccident inspections of both carriers and that resulted in their temporary shutdown. The FAA has developed considerable information on cargo-related problems from the results of two special emphasis ramp checks conducted after the Fine Air accident. However, the FAA Administrator noted in a March 3, 1998, memorandum that "much work remains to correct systemic problems with FAA's aviation safety inspection program." Further, FAA representatives told Safety Board investigators that "data collection, analysis and corrective actions are not well focused." The results of this investigation indicate that these deficiencies apply to both local FSDO surveillance and to NASIP and RASIP inspections. Thus, the Safety Board concludes that NASIP and RASIP inspections are not adequately identifying and addressing systemic safety problems that exist in air carrier operations at the time the inspections are conducted. Therefore, the Safety Board believes that the FAA should review its NASIP and RASIP inspection procedures to determine why inspections preceding these accidents failed to identify systemic safety problems at ValuJet and Fine Air and, based on the findings of this review, modify these inspection procedures to ensure that such systemic indicators are identified and corrected before they result in an accident.

The Safety Board notes current FAA initiatives to redesign and improve FAA oversight of air carriers, including the development and implementation of the Air Transportation Oversight System (ATOS) program designed to target resources and inspections to identify systemic safety problems. The Safety Board is also encouraged by the FAA's recent enforcement actions against cargo carriers based on standards developed after the Fine Air accident. Also encouraging are FAA proposals to better focus geographic inspector surveillance, planned changes in the new entrant carrier certification process and improved methods for the collection, analysis, and inspector access to FAA surveillance and safety trend data (the more effective use and dissemination of safety performance analysis system and program tracking and reporting system data). Although these and other proposed changes are in response to Safety Recommendation A-96-163, issued following the 1995 Tower Air accident, are steps forward, the Safety Board is concerned that some operators that may benefit most from additional scrutiny have not been included in the initial implementation phases of the ATOS program. The program is being launched at 10 of the nation's largest carriers, for which FAA surveillance is already considerable, and operational incidents and accidents are relatively rare.

Although it is understandable why the FAA wants to "refine the new model" before expanding to other sectors of the industry, the Safety Board is nevertheless concerned about the potential for delays inherent in the implementation of such a comprehensive redesign of the FAA surveillance system. Initial implementation at the 10 designated carriers is not scheduled until October 1998. Although the proposed changes to the FAA oversight system address the intent of Safety Recommendation A-95-163, the Safety Board will continue to monitor the FAA's progress in implementing these changes. Pending further action, the Safety Board reiterates its February 23, 1998, classification of Safety Recommendation A-95-163 as "Open—Acceptable Response."

However, the Safety Board remains concerned about the FAA's ability to successfully enhance its surveillance capability at current budget and personnel resource levels, especially at a time when the aviation industry is growing rapidly and increasing demands are being placed on the agency's certificate management system. Indeed, principal inspectors assigned to Fine Air stated that they needed assistance in accomplishing their tasks and that the number of en route inspections they conducted were reduced because of scheduling, workload, and budget constraints. Following a February 16, 1995, accident involving an Air Transport International DC-8-63, the Safety Board issued Safety Recommendation A-95-111, which asked the FAA to determine whether its budget and personnel resources were sufficient to maintain its surveillance programs adequately. Although the Safety Board in 1996 classified A-95-111 "Closed—Acceptable Action" following an FAA response stating that resources were "properly allocated to maintain oversight at an adequate level," the Safety Board concludes that, based on its investigation of the Fine Air accident, current FAA personnel and budget resources may not be sufficient to ensure that the quality of air carrier surveillance will improve. Therefore, the Safety Board believes that the FAA should evaluate the surveillance programs to ensure that budget and personnel resources are sufficient and used effectively to maintain adequate oversight of the operation and maintenance of both passenger and cargo carriers, irrespective of size.

Loss of FDR Data

The failure of the accident airplane's FDR to record 6 of the 11 required parameters of data hampered the Safety Board's investigation into the pitch-up and stall events that resulted in the airplane's departure from controlled flight. The FDR did not record information about engine data, airspeed, pitch and roll attitudes, vertical acceleration, and microphone keying, all of which would have been immensely useful in understanding the accident scenario.

The Safety Board has long been concerned about problems related to the absence of FDR data critical to accident investigations and has made a series of recommendations beginning in the early 1970s to improve FDR accuracy, expand the number of parameters, and require verification of parameter recordings. Continued concerns about the airworthiness of FDRs resulted in the Safety Board's issuing two recommendations to the FAA in 1991 (Safety Recommendations A-91-23 and -24) aimed at developing a permanent policy for FDR maintenance and recordkeeping. Further, in 1997, following a series of accidents that involved problems with recordings on retrofitted FDRs, the Safety Board issued two additional safety recommendations (Safety Recommendations A-97-29 and -30) asking the FAA to require readouts of retrofitted 11-parameter FDRs to ensure that all required parameters were being recorded properly and to complete, by January 1998, an FAA-promised AC addressing the installation and maintenance of FDRs.

The problems with the Fine Air FDR in this accident once again underscore the need for prompt action in determining the functionality and airworthiness of retrofitted 11-parameter FDRs, the importance of FDR certification and maintenance requirements, and the importance of accurate FDR documentation. In the case of Fine Air, in addition to the six parameters that were missing, the heading data were recorded on three parameters and in reverse. The Safety Board notes with concern that these deficiencies were found less than 4 months after a maintenance examination of the FDR that required the unit to be "downloaded into a computer capable of determining that all parameters are being recorded" and 3 months after it was overhauled and bench checked.

The Safety Board also notes with disappointment that the AC promised by the FAA to be issued by January 1998 has not yet been completed, even though the Safety Board provided a draft version of the AC upon request by FAA staff. The Safety Board has stated several times that inclusion of guidance relating to FDR maintenance documentation (which was addressed in FAA Notice N8110.65) into this AC would satisfy the intent of Safety Recommendations A-91-23 and -24. An AC addressing FDR maintenance and FDR certification would also satisfy the intent of Safety Recommendation A-97-30. However, the Safety Board is concerned that the AC, already delayed more than 7 years, still may not be produced in a timely manner. This AC is also essential to reduce retrofit problems that could occur on a much larger scale than those encountered during the less-sophisticated 11-parameter retrofit program. Accordingly, the Safety Board classifies Safety Recommendations A-91-23, A-91-24, and A-97-30 "Open—Unacceptable Response" pending the FAA's completion of the AC.

The Safety Board is also disappointed with the adequacy of the FAA's response to determine the airworthiness of retrofitted, 11-parameter FDRs, as requested in Safety Recommendation A-97-29 in May 1997. Although the FAA stated in a July 1997 response letter that it agreed with the intent of the recommendation and planned to require air carriers to perform readouts of all retrofitted 11-parameter FDRs within 180 days of the issuance of a new FDR flight standards bulletin (which became effective on December 15, 1997), the timetable intended for these readouts was not specified. For example, HBAW-97-13B, issued in response to Safety Recommendation A-97-29, made no mention of the 180-day timetable for readouts and only proposed scheduling FDR maintenance at "C" check intervals as part of the new FDR maintenance program guidelines it outlined.[16] Under the "C" check interval inspection plan described in the bulletin, Fine Air flight 101's FDR might not have been due for inspection until January 2001. This timeframe for completing a full readout of 11-parameter FDRs is not acceptable and does not address the intent of Safety Recommendation A-97-29.

Recent events suggest that the necessity for these readouts remains. Since the Fine Air accident, the Safety Board encountered yet another malfunction involving an 11-parameter retrofit, installed on an American Airlines Boeing 727 that landed short of runway 14R at O'Hare International Airport, in Chicago, Illinois, on February 9, 1998. Although the investigation is not complete, an initial readout of the accident airplane's FDR determined that data recorded on the elevator/pitch and longitudinal acceleration parameters were unuseable, resulting in the loss of information potentially critical to determining the cause of the accident. The Safety Board notes that this FDR malfunction occurred on an airplane maintained by a large international air carrier with extensive maintenance resources and substantial FAA oversight. FDR system documentation provided by the airline indicates that the elevator position sensor might have been installed incorrectly, and that this condition was not discovered during a functional test conducted at a "C" check in November 1997. Examination of the elevator parameter data suggested that the person who performed the functional test either wrote the results in the wrong place or that the elevator values were reversed, with the value for "full column forward" in the correct value range for "full column aft" and vice-versa. Although the Safety Board has not yet drawn a conclusion regarding the ground test, the Safety Board is concerned that these malfunctions might have resulted in improper parameter installation and/or maintenance.[17]

The Fine Air accident also highlights the importance of proper documentation of FDR maintenance actions and readout results. Although Fine Air's maintenance manual required that the accident airplane's FDR data be downloaded into a computer to determine that the parameters were being recorded properly, the maintenance job card that tracked the work

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[16] At Fine Air, a C check interval occurs every 3,300 hours, or 36 months.

[17] Examination of the data recorded on the longitudinal acceleration parameter indicated that the data were more representative of data for lateral acceleration, suggesting that the accelerometer might have been incorrectly installed on the airplane, resulting in lateral, rather than longitudinal, data being recorded.

performed did not require this readout data to be printed or retained. Only a mechanic's signature was required to certify that the readout had been accomplished. Consequently, there was no way for another person to verify that the readout was correct. The Safety Board concludes that permanent documentation of FDR computer readouts is needed to later verify that such readouts have been properly accomplished.

Based on the continued discovery of malfunctioning 11-parameter FDRs and because the findings of this accident investigation indicate that it is advisable to require air carriers to maintain the records of FDR readouts, the Safety Board classifies Safety Recommendation A-97-29 "Closed—Unacceptable Action/Superseded" and believes that the FAA should require an immediate readout of all 11-parameter retrofitted FDRs to ensure that all mandatory parameters are being recorded properly; that the FDR system documentation is in compliance with the range, accuracy, resolution, and recording interval specified in 14 CFR Part 121, Appendix B; and require that the readout be retained with each airplane's records.[18]

The number of recent confirmed FDR malfunctions also suggests that the problem may go well beyond the scope of 11-parameter retrofits. Indeed, the number of problems encountered with 11-parameter FDRs suggests either inadequate installations or maintenance of FDR systems. The Safety Board is concerned that the problems encountered with 11-parameter FDR retrofits will not only continue, but worsen, without further corrective action as additional mandated parameters are added according to phase-in requirements under 14 CFR Part 121.343 and Appendix B.[19] Thus, the Safety Board concludes that current and proposed inspection intervals for FDRs (at each "C" check) are not adequate because of fleet utilization variables at many carriers. Therefore, the Safety Board believes that the FAA should require maintenance checks for all FDRs of aircraft operated under 14 CFR Parts 121, 129, 125, and 135 every 12 months or after any maintenance affecting the performance of the FDR system, until the effectiveness of the proposed AC and new FAA inspector guidance on continuing FDR airworthiness (maintenance and inspections) is proven; further, these checks should require air carriers to attach to the maintenance job card records a computer printout, or equivalent document, showing recorded data, verifying that the parameters were functioning properly during the FDR maintenance check and require that this document be part of the permanent reporting and recordkeeping maintenance system.

Although an FDR's primary function is to provide detailed flight information following an accident or incident, this detailed flight information is useful even in the absence of an accident or incident. The Safety Board notes that the FDR phase-in requirement and the quick access capabilities of modern solid-state FDRs offer operators the opportunity to develop and implement a flight operations quality assurance (FOQA) program. Analysis of downloaded

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[18] Appendix B outlines FDR specifications, including parameters, range, accuracy, sampling interval, and resolution.

[19] Under Part 121.343, all airplanes manufactured on or before October 11, 1991, with 30 or more seats will be required to have FDRs equipped with 22 channels (or 18 for those units that do not have flight data acquisition unitss no later than August 18, 2001). Airplanes manufactured after October 11, 1991, up to August 18, 2000, will be required to have FDRs with 34 channels. Transport airplanes manufactured between 2000 and 2002 will be required to have 57-parameter FDRs, and airplanes manufactured after August 18, 2002, will be required to have 88-parameter FDRs.

FOQA data enables operators to enhance crew and aircraft performance, to develop tailored training and safety programs, and to increase operating efficiency. FOQA programs can also be used to refine ATC procedures and airport configurations and to improve aircraft designs. Although FOQA programs based on the minimum 18 parameters called for in the FDR phase-in requirements would have some limitations, the potential safety and operational benefits of even a limited program are significant.

Because frequent FDR data downloads and data analysis are components of a viable FOQA program, the requirement for periodic readouts to validate the quality of the mandatory FDR parameters would likely be met if the operator corrected recording problems discovered in the readout. The need to download and analyze FDR would also require operators to maintain sufficient FDR system documentation to meet the Safety Board's needs in the event of an accident or incident.

In a May 1997 letter to the FAA, the Safety Board listed a series of accidents and incidents from 1991 through 1997 that involved problems extracting data from retrofitted FDRs. Because many of the problems encountered with retrofitted FDRs have resulted from improper installation and poor system documentation, the Safety Board is concerned that deficiencies may exist in the supplemental type certificate (STC) process; and that retrofit errors and problems are not being identified and corrected by FAA inspectors.[20] An FDR's primary function is to provide detailed flight information following an accident or incident; it does not otherwise affect the airworthiness of an aircraft. As a result, air carrier maintenance technicians may not view the FDR system as critical to the operation of the airplane, and FAA avionics inspectors may have little or no exposure to the complex data collection and recording features of FDR systems. Thus, the Safety Board concludes that FAA principal avionics inspectors (PAIs) may lack the experience and training to provide adequate oversight of FDR installations and continued FDR airworthiness requirements. Therefore, the Safety Board believes that the FAA should provide FAA PAIs with training that addresses the unique and complex characteristics of FDR systems. Further, the Safety Board believes that the FAA should create a national certification team of FDR system specialists to approve all STC changes to FDR systems.

Deficiencies in Fine Air's CAS Maintenance Program

A Safety Board review of the accident airplane's maintenance logs for the 90-day period before the accident indicated a significant number of recurring problems involving the engines, belly cargo doors, and thrust reversers. Although none of these problems were factors in the accident, the Safety Board is concerned because the continuing analysis and surveillance (CAS) program was designed to alert operators to repeat deficiencies and to facilitate prompt corrective maintenance action in problem areas. Fine Air's director of quality control stated that these repetitive repairs often involved "different parts" of "an old system." However, the number and similarity of the maintenance discrepancies on the accident airplane suggests that repeated problem indicators were either missed or ignored. Thus, the Safety Board concludes that Fine Air's CAS program was not as rigorous as its program description indicated and failed to result

[20] An STC authorizes alteration of an aircraft engine or other component that is operated under an approved-type certificate.

in the correction of systemic maintenance deficiencies. Therefore, the Safety Board believes that the FAA should direct the PMI assigned to Fine Air to reexamine the airline's CAS program and take action, if necessary, to ensure that repetitive maintenance discrepancies are being identified and corrected.

The Safety Board's review of the accident airplane's maintenance logs also found that all significant maintenance discrepancies were logged by flightcrews on return trips to Miami, where Fine Air's maintenance facilities are located. No significant entries were made at any outstation location. The FAA PMI assigned to Fine Air told Safety Board investigators that he had "raised concerns" with Fine Air management about flightcrews "having all their problems on final in Miami," adding that proving when the discrepancies actually occurred was impossible unless the inspector was accompanying the flightcrew on an en route inspection. In addition, an FAA PMI based in Milwaukee, Wisconsin, stated that such log entries "are common every day practice...if you're passenger or freight, that's standard." This inspector also described the difficulty inspectors encounter when trying to enforce proper logbook entry procedures, asking "how do you do something about it [prove the entries were intentionally deferred until the return leg]." In the case of Fine Air, the Safety Board found no evidence that corrective action was taken by the airline after the PMI raised his concerns to Fine Air management and no evidence of further FAA followup on the matter.

During its investigation of an uncontained engine failure on a Delta Air Lines MD-88,[21] the Safety Board determined that flightcrew members who found drops of oil on an engine bullet nose and two missing wing rivets did not have clear guidance on what constituted "maintenance 'discrepancies' and 'irregularities' and when to contact maintenance personnel and to log anomalies." Although the captain's decision to defer maintenance in Pensacola (the departure airport) until arrival in Atlanta, a Delta hub, appeared to have been contrary to Delta's FOM, Delta management later supported the flightcrew's failure to log the discrepancies or to contact maintenance.

The Safety Board is concerned that this return leg logging practice, which may be as widespread in the industry as it is difficult to verify, has become an unspoken, and largely tolerated, way of avoiding costly outstation repairs and flight delays. Safety Recommendation A-98-21, issued to the FAA as a result of the investigation of the Delta accident, was aimed at clarifying flightcrew responsibilities and when flightcrews "can, if at all, make independent determinations to depart when maintenance irregularities are noted." The recommendation called for POIs to review and clarify these policies at their respective operators. However, these policies may differ significantly among operators. Moreover, 14 CFR Part 121.363,[22] while outlining the airworthiness responsibilities of operators, contains no specific requirement to ensure that maintenance discrepancies are logged when they are discovered. According to 14 CFR Part

[21] National Transportation Safety Board. 1998. *Uncontained Engine Failure, Delta Air Lines Flight 1288, McDonnell Douglas MD-88, N927DA, Pensacola, Florida, July 6, 1996.* Aircraft Accident Report NTSB/AAR-98/01. Washington, DC.

[22] Part 121.363, "Responsibility for Airworthiness," states that "each certificate holder is primarily responsible for...the airworthiness of its aircraft...[and] the performance of the maintenance, preventive maintenance...in accordance with its manual and the regulations of this chapter."

121.563, the pilot in command is required to "ensure that all mechanical irregularities occurring during flight time are entered in the maintenance log of the airplane at the end of that flight time" and to "ascertain the status of each irregularity entered in the log at the end of the preceding flight." The Safety Board is concerned that the term "flight time" is not specifically defined, and could be interpreted by flight crews as meaning at the end of the last flight of a multiple-leg duty day, instead of at the end of the flight during which the irregularity was discovered. Part 121.563 also does not address irregularities and specific logging responsibilities for irregularities found during preflight inspections.

Faced with a maintenance irregularity at an outstation, flightcrews (under schedule pressures and perhaps a management preference for home-base repairs when possible) may be reluctant to risk the delay that a logbook entry could incur. Language addressing specific logging requirements in Part 121.563 (that defined specific logging requirements or stated that logging is mandatory, rather than referring only to the general airworthiness of the airplane) would reduce ambiguity. This would require flightcrews, especially at outstations, to contact maintenance for a deferral or a decision to seek contract maintenance repairs before departing. Although there may be circumstances in which independent flightcrew evaluation of maintenance discrepancies is warranted, maintenance personnel are the best qualified personnel to make such determinations. Thus, the Safety Board concludes that Fine Air's maintenance logs for the accident airplane suggest a practice of logging significant maintenance discrepancies on return flights to Miami, where repairs were completed, and that such practices may be widespread in the industry. Further, the Safety Board concludes that although the PMI noted a pattern of logging entries on return flights to Miami and expressed his concerns to Fine Air management, no further action was taken either by the PMI or Fine Air management to address this problem. Therefore, the Safety Board believes that the FAA should amend 14 CFR Part 121.563 to specifically require that all discrepancies be logged when they occur and be resolved before departure through repair or deferral in consultation with (the certificate holder's or contracted) maintenance personnel.

As a result of the investigation of this accident, the National Transportation Safety Board recommends the following to the Federal Aviation Administration:

> Require all 14 Code of Federal Regulations Part 121 air carriers to provide flightcrews with instruction on mistrim cues that might be available during taxi and initial rotation, and require air carriers using full flight simulators in their training programs to provide flightcrews with Special Purpose Operational Training that includes an unanticipated pitch mistrim condition encountered on takeoff. (A-98-44)
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> Conduct an audit of all Code of Federal Regulations Part 121 supplemental cargo operators to ensure that proper weight and balance documents are being used, that the forms are based on manufacturer's data or other approved data applicable to the airplane being operated, and that FAA principal inspectors confirm that the data are entered correctly on the forms. (A-98-45)
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> Require carriers operating under 14 Code of Federal Regulations Part 121 to develop and use loading checklists to positively verify that all loading steps have

been accomplished for each loaded position on the airplane and that the condition, weight, and sequencing of each pallet is correct. (A-98-46)

Require training for cargo handling personnel and develop advisory material for carriers operating under 14 Code of Federal Regulations Part 121 and principal operations inspectors that addresses curriculum content that includes but is not limited to, weight and balance, cargo handling, cargo restraint, and hazards of misloading and require all operators to provide initial and recurrent training for cargo handling personnel consistent with this guidance. (A-98-47)

Review the cargo loading procedures of carriers operating under 14 Code of Federal Regulations Part 121 to ensure that flightcrew requirements for loading oversight are consistent with the loading procedures in use. (A-98-48)

Evaluate the benefit of the STAN (Sum Total Aft and Nose) and similar systems and require, if warranted, the installation of a system that displays airplane weight and balance and gross weight in the cockpit of transport-category cargo airplanes. (A-98-49)

Require all principal inspectors assigned to 14 Code of Federal Regulations Part 121 cargo air carriers to observe, as part of their annual work program requirements, the complete loading operation including cargo weighing, weight and balance compliance, flight following, and dispatch of an airplane. (A-98-50)

Review its national aviation safety inspection program and regional aviation safety inspection program inspection procedures to determine why inspections preceding these accidents failed to identify systemic safety problems at ValuJet and Fine Air and, based on the findings of this review, modify these inspection procedures to ensure that such systemic indicators are identified and corrected before they result in an accident. (A-98-51)

Evaluate the surveillance programs to ensure that budget and personnel resources are sufficient and used effectively to maintain adequate oversight of the operation and maintenance of both passenger and cargo carriers, irrespective of size. (A-98-52)

Require an immediate readout of all 11-parameter retrofitted flight data recorders (FDRs) to ensure that all mandatory parameters are being recorded properly; that the FDR system documentation is in compliance with the range, accuracy, resolution, and recording interval specified in 14 Code of Federal Regulations Part 121, Appendix B; and require that the readout be retained with each airplane's records. (A-98-53)

Require maintenance checks for all FDRs of aircraft operated under 14 Code of Federal Regulations Parts 121, 129, 125, and 135 every 12 months or after any maintenance affecting the performance of the FDR system, until the effectiveness of the proposed advisory circular and new FAA inspector guidance on continuing FDR airworthiness (maintenance and inspections) is proven; further, these checks should require air carriers to attach to the maintenance job card records a computer printout, or equivalent document, showing recorded data, verifying that the parameters were functioning properly during the FDR maintenance check and require that this document be part of the permanent reporting and recordkeeping maintenance system. (A-98-54)

Provide FAA principal avionics inspectors with training that addresses the unique and complex characteristics of flight data recorder systems. (A-98-55)

Create a national certification team of flight data recorder (FDR) system specialists to approve all supplemental type certificate changes to FDR systems. (A-98-56)

Direct the principal maintenance inspector assigned to Fine Air to reexamine the airline's continuing analysis and surveillance program and take action, if necessary, to ensure that repetitive maintenance discrepancies are being identified and corrected. (A-98-57)

Amend 14 Code of Federal Regulations Part 121.563 to specifically require that all discrepancies be logged when they occur and be resolved before departure through repair or deferral in consultation with (the certificate holder's or contracted) maintenance personnel. (A-98-58)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 21, 1998

In reply to refer to: A-98-59 through -61

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

Since 1983, the National Transportation Safety Board has investigated 145 accidents involving aerial advertising/banner towing. Forty-five of the accidents (31 percent) resulted in 37 fatalities and 11 serious injuries. A recent review of the accidents by the Safety Board indicated that a majority of the accidents were associated with one or more of the following critical flight phases, circumstances, or events: the banner pickup maneuver, entangled or snarled banner tow lines, and loss of engine power.

Banner Pickup Maneuver (63 accidents)

The banner pickup maneuver is a critical low-level maneuver performed about 20 feet above the ground in which, while trailing a grapple hook, the pilot flies above and between two upright poles about 15 to 20 feet apart. The pilot's objective is to engage the banner tow loop (suspended between the poles) by applying full power and abruptly pitching the airplane upward just before arriving at the pickup poles. The banner, laid out on the ground, is connected to a tow line about 250 feet long. To lift the banner into the air and to avoid dragging it along the ground, the pilot exchanges speed energy for altitude, attempting to gain as much altitude as possible before moving the banner. The airspeed decreases rapidly during the maneuver because of the airplane's nose-high pitch attitude. As the airspeed approaches the best angle-of-climb airspeed, the pilot must begin lowering the nose of the airplane to avoid a stall. However, for a variety of reasons, including inadequate pickup airspeed, excessive pitch attitude, and delay in reducing pitch attitude, about 50 percent of the accidents involving this maneuver result in a stall or a stall/spin and a subsequent collision with the ground. The fundamental problem is largely operational, involving banner pilot training, experience, and competence issues.

Entangled or Snarled Banner Tow Lines (32 accidents)

A grapple hook and cable assembly, the device used to engage the tow line during the banner pickup, is about 30 feet long. One end of the cable is attached to the tow release mechanism on the tail of the airplane adjacent to the rudder control horns. Typically, the grapple hook and cable are brought forward along the side of the fuselage and through the cockpit window; they are stowed in the cockpit until the airplane is airborne and the pilot is ready to pick up the banner. The pilot then drops the hook and cable, allowing it to trail into position below and behind the airplane. However, if the hook and cable pass too closely to the side of the fuselage, the assembly sometimes becomes entangled or wrapped around the rudder control horns and disables the tow release mechanism. If the banner is picked up with the cable entangled in this manner, it causes significant loading and deflection of the rudder control horns and rudder, which leads the airplane to yaw severely. About 80 percent of the accidents involving entangled banner tow lines result in an in-flight loss of control and a subsequent collision with the ground or a loss of airplane performance and control during landing.

Loss of Engine Power (31 accidents)

A partial or total loss of engine power can occur because of fuel exhaustion, fuel starvation, fuel contamination, inadequate maintenance, or mechanical failure. Because typical banner towing operations are performed at relatively low altitudes, the loss of engine power usually allows the pilot little time to initiate emergency procedures, release the banner tow line, or position the airplane for a successful forced landing. About 40 percent of the accidents precipitated by loss of engine power involved in-flight collisions with objects/terrain; 20 percent involved an in-flight loss of control. The airplane was ditched (landed in the water) in 13 of the accidents.

Banner towing operations are conducted under a certificate of waiver or authorization issued by the Federal Aviation Administration (FAA) in accordance with Title 14 Code of Federal Regulations (CFR) 91.311, "Towing-Other Than Gliders." The respective FAA flight standards district office (FSDO) issuing the banner towing certificate may append special provisions to the certificate in the interest of safety if the operator uses nonstandard equipment or for other reasons such as geographical considerations, pilot limitations, air traffic control limitations, or weather conditions. The Safety Board is aware of one FSDO that appends special provisions concerning banner pilot minimal training and safety equipment to all banner towing certificates.

Operators who hold a certificate of waiver or authorization have the responsibility to train each new pilot in banner tow operations and in the special provisions of the waiver. However, there are no specific regulatory requirements or other guidelines, such as an FAA advisory circular (AC), that uniquely address banner tow training or operations. The amount of training given and the training syllabus used, if any, is largely at the discretion of the individual operators. The FAA requires that the new banner tow pilots demonstrate proficiency by performing one banner pickup and drop with the maximum number of letters (panels) to be used by the certificate holder. However, repeated accidents involving inadequate pilot performance (failure to maintain airspeed, misjudgment of clearance, etc.) during the banner pickup maneuver indicate a lack of adequate training and proficiency in performing the maneuver under both normal and abnormal (entangled banner) circumstances.

Although very few formal or structured banner towing training courses are available, the Safety Board is aware of one course[1] that has been approved by the FAA under 14 CFR Part 141, "Pilot Schools." The curriculum, which contains comprehensive ground and flight training designed to enable pilots to safely tow commercial banners, is described as follows:

> Complete ground school on all related subjects, including FARs, waiver requirements, banner assembly, pre-and-post-flight of aircraft, banner tow equipment and banners, repair to banners and equipment, communications, emergency procedures, ground crew coordination and marketing. Flight training includes pick-up and drop procedures, in-flight emergencies involving banner towing, normal procedures, and abnormal procedures. Includes actual banner towing missions and ample practice banner pick-ups and drops.

The lesson syllabus includes repeated low passes (over the banner pickup zone) with emphasis on altitude and airspeed control, maximum performance maneuvers, failure of the tow release mechanism, loss of rudder control, repeated pickup and drop of the banner tow line (with and without the banner attached), and loss of engine power with the banner attached. Because of the history of accidents involving banner towing, which indicates that current training procedures are inadequate, the Safety Board believes that the FAA should require banner tow operators to train new banner tow pilots using an FAA-approved banner tow training syllabus, similar to the one above.

The Safety Board also believes that the FAA should issue a comprehensive aerial advertising/banner towing AC containing detailed information concerning FAA regulations and requirements; banner towing equipment and flight operations, including tow hitch and release mechanisms; banner assembly size and weight considerations, layout, and banner aircraft performance limitations; flight training guidelines/criteria for safe and efficient performance of the banner pickup maneuver and other phases of banner towing operations; fuel management; in-flight emergencies, including entangled/snarled banner tow lines and loss of engine power; and aircraft, engine, and banner equipment maintenance requirements.

The hazards caused by banner tow lines becoming entangled with the rudder control horns and/or tow release mechanism can be avoided through use of simple mechanical devices.[2] For example, for tail wheel airplanes with horizontal stabilizer support wires, a spring-action clip can be fastened to the lower stabilizer wire near the point where it joins the outboard bottom surface of the stabilizer. The tow cable may then be routed from the tow release mechanism outboard to the spring clip and then forward to the cockpit, ensuring that the cable is held away from the fuselage when the grapple hook and cable assembly are dropped. The weight of the hook and cable then pulls the cable away from the spring clip, and the cable trails normally behind and below the airplane.

A second device consists of a guard attached to the bottom of the fuselage projecting outward and aft from either side of the fuselage. This can be fabricated from a steel rod 1/4 to 3/8 inch in diameter bent at the center to form a "V." A small plate welded to the rod at the bend

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[1] *Banner Tow Training*, Kaimana Aviation, Inc., Ponca City, Oklahoma 74601.

[2] Refer to *Instruction Booklet for Gasser Banner Equipment*, Gasser Banner, Inc., Nashville, Tennessee 37217.

serves as a base for attachment to the fuselage. The length and spread of the "V" is designed so that a tow cable sliding along the side of the fuselage toward the rear would be deflected outward around the rudder control horns and clear of the steering arms and springs.

Because these devices can prevent banner tow lines from becoming entangled with the rudder control horns and/or tow release mechanisms, the Safety Board believes that the FAA should require the installation of a mechanical safety device on the tails of tow airplanes such as a V-bar guard or stabilizer wire spring clip, designed to prevent entanglement of the banner grapple hook/cable assembly with the airplane's rudder control horns and/or tow release mechanism.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require banner tow operators to train new banner tow pilots using an FAA-approved banner tow training syllabus. The training syllabus should include repeated low passes (over the banner pickup zone) with emphasis on altitude and airspeed control, maximum performance maneuvers, failure of the tow release mechanism, loss of rudder control, repeated pickup and drop of the banner tow line (with and without the banner attached), and loss of engine power with the banner attached. (A-98-59)
>
> Issue a comprehensive aerial advertising/banner towing advisory circular containing detailed information about FAA regulations and requirements; banner towing equipment and flight operations, including tow hitch and release mechanism, banner assembly size and weight considerations layout, and banner aircraft performance limitations; flight training guidelines/criteria for safe and efficient performance of the banner pickup maneuver and other critical phases of banner towing operations; fuel management; in-flight emergencies, including entangled/snarled banner tow lines and loss of engine power; and aircraft, engine, and banner equipment maintenance requirements. (A-98-60)
>
> Require the installation of a mechanical safety device on the tails of tow airplanes such as a V-bar guard or stabilizer wire spring clip, designed to prevent entanglement of the banner grapple hook/cable assembly with the airplane's rudder control horns and/or tow release mechanism. (A-98-61)

Chairman HALL and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations. Vice Chairman FRANCIS concurred with recommendation A-98-60, but disapproved recommendations A-98-59 and -61.

By: Jim Hall
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 31, 1998

In reply refer to: A-98-62 through 64

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On February 17, 1998, the right main landing gear (MLG) of a Boeing 757-200 (757) airplane, operated by Canada 3000 on an intended passenger charter flight from Brussels, Belgium, to Montreal, Canada, collapsed while the airplane was taxiing for takeoff at Brussels International Airport. None of the occupants were injured and the airplane sustained minor damage. The airplane had accumulated 11,450 cycles and 42,196 hours in 8 years and 9 months of service.

The National Transportation Safety Board is participating in the Belgian Civil Aviation Administration's investigation of the incident, in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation. Postincident examination of the right MLG revealed a circumferential fracture on its truck beam, which had broken into two large sections. The examination of the fracture surfaces revealed intergranular stress corrosion cracking (SCC) emanating from corrosion pits on the lower inside diameter of the truck beam. Examination of the inside surface of the truck beam revealed multiple localized areas where the primer painted on the inside surface had deteriorated, bubbled-up, or was missing.

The 757 MLG is a conventional, four-wheel, dual-tandem landing gear that has a metering pin orifice shock strut (see figure 1). The gear has four support points: the forward trunnion, the aft trunnion, the drag brace, and the side strut. The shock strut outer cylinder of the MLG assembly transfers operational loads from the truck assembly to the four support points. The assembly consists of a truck beam, axles, wheels and tires, brake rods, and a protective shield. The truck beam is the primary supporting member of the truck assembly. It pivots on the lower end of the shock strut outer cylinder.

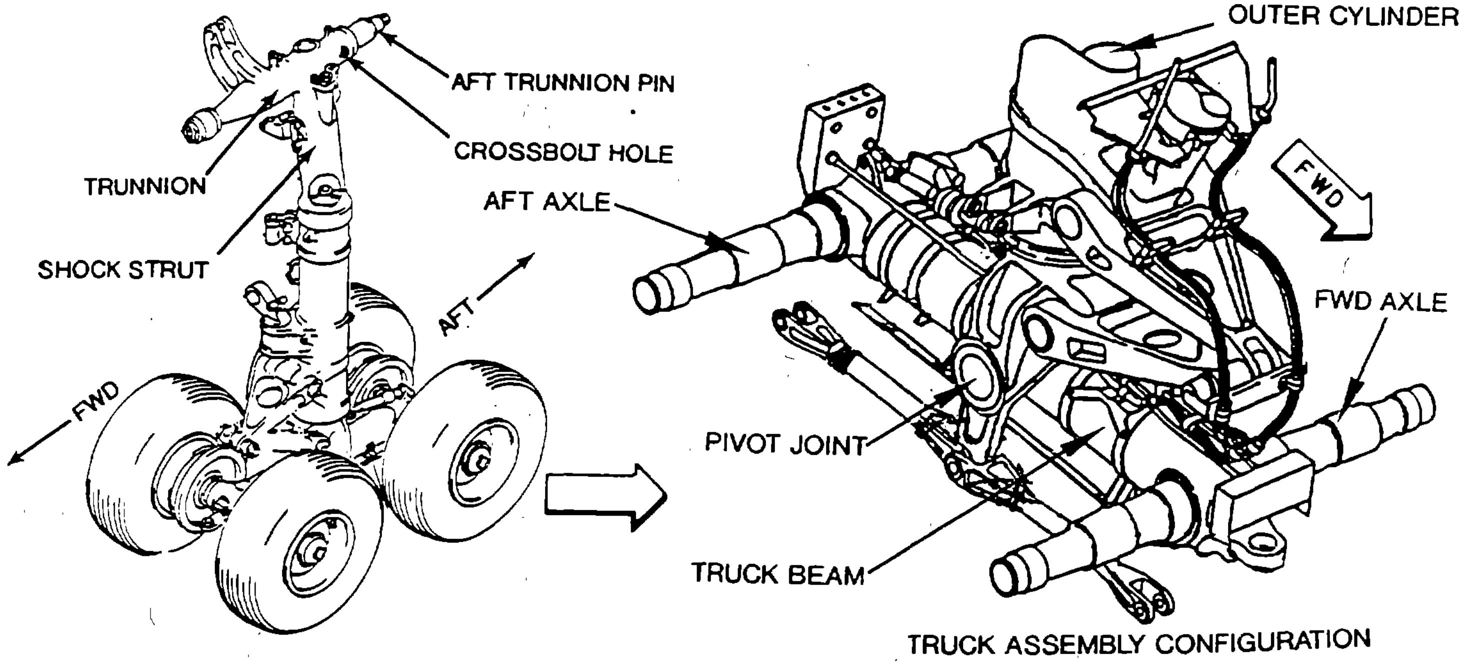

Figure 1. Boeing 757 Main Landing Gear Assembly

The truck beam is a hollow cylinder made from 4340M steel. The inner surface has three primary means of corrosion protection: cadmium-titanium electroplating; Boeing Material Specification BMS10-11 type 1 primer; and MIL-C-11796 Class 1 corrosion-inhibiting compound (CIC), also called Cosmoline. This CIC is applied in a hot liquid form and coats the inner surface of the truck beam with a uniform layer. Any moisture in the truck beam is drained through an opening at the aft end of the cylindrical truck beam section by gravity during truck tilt during takeoff.

The Safety Board's materials laboratory examined the right MLG truck beam and found three anomalies: missing primer, missing CIC, and a plugged drainage opening. About 75 percent of the inner surface of the truck beam was missing CIC, exposing the primer. There were localized spots of corrosion and exposed bare metal where the primer was missing. The primer was missing primarily on the bottom inner surface of the truck beam. In this area, some remaining primer had bubbled up and could easily be scraped off. Both ends of the truck beam contained approximately 2-inch diameter globules of CIC and grease. These globules and a dirt/grease mixture had clogged the truck beam's drainage opening.

The examination of the fracture surfaces disclosed a 0.9-inch wide region that showed characteristics of SCC. The primer was missing on the inner surface of the truck beam in the SCC area. Scanning electron microscope examination of the 0.9-inch wide SCC fracture region disclosed intergranular features, typical of SCC in 4340M steel, that emanated from three corrosion pits on the inner diameter surface. These corrosion pits measured no more than 0.01 inch deep by 0.01 inch diameter. The rest of the fracture area exhibited river pattern features characteristic of overstress.

Examination of the left MLG of the incident airplane at the overhaul facility revealed large globules of grease and CIC clogging the truck beam drainage opening similar to that found in the right MLG. The CIC had separated from the inner surface and there were patches of corrosion and areas where the primer was missing. The surface corrosion on the inner surface of the left MLG truck beam was more extensive than that found on the right MLG.

Boeing records indicate no other 757 MLG truck beam failures from SCC. Following this incident, the Safety Board contacted various 757 MLG overhaul facilities and was informed that typically 757 MLGs are inspected and overhauled after 8 to 10 years of service. Boeing's Maintenance Planning Document[1] for the 757 recommends the disassembly/restoration of the MLG between 12,000 and 18,000 cycles, or 10 years, whichever occurs first. The overhaul facilities informed the Safety Board that at overhaul, almost all 757 MLG truck beam inner surfaces exhibit patches of corrosion, but the primer and CIC are normally present. The overhaul facilities reported that globules of grease and CIC had not been found in any MLG truck beam that they had overhauled. The overhaul facilities reported that the truck beam drainage opening was found clogged in some MLGs that had been brought in for overhaul, but Boeing has informed the Safety Board that there have been a few isolated cases in which the CIC has separated from the truck beam inner surface and the primer has remained intact.

According to Boeing, if the CIC or primer separates from the inner surface, the corrosion protection capability is reduced. Also, if the gravity drain opening is clogged, the truck beam will retain ingested moisture creating an environment conducive to corrosion and SCC. The 757 maintenance manual does not specify a way to determine the condition of the corrosion protection layers (i.e., CIC and primer) or the gravity drainage opening of the MLG truck beam before overhaul. Because moisture is one of the primary causes of corrosion and can easily be ingested into the truck beam, it is important to eliminate it by preventing the drain opening from becoming blocked. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require operators of 757s to conduct periodic inspections of the MLG truck beam to ensure that the drainage opening at the aft end of the beam is unobstructed.

The balling up of the CIC and the loss of the primer from the interior surface of the truck beam resulted in the corrosion protection deteriorating over much of the surface of the beam, including the area where the stress corrosion cracking initiated. The presence of moisture and aggressive contaminants trapped within the beam by blockage of the drainage opening probably accelerated the deterioration of the corrosion protection and created an environment that led to the initiation of the stress corrosion cracking. A periodic visual inspection of the truck beam inner surface is important to detect the condition of the CIC and primer to minimize the possibility of corrosion or SCC in the beam. Also, to ensure detection of corrosion and cracking on the inner surface of the 757 truck beam, a nondestructive

[1] The Boeing Maintenance Planning Document provides general guidance to airlines in the formulation and establishment of individual maintenance programs.

inspection (NDI) technique should be developed and implemented. The Safety Board is aware that Boeing and other operators have developed NDI techniques to detect corrosion and cracks in the trunnion bore of the 767 MLG, and the FAA has mandated the inspection.[2] A similar technique could be developed to detect corrosion and cracks on the inner surface of 757 truck beams. Because no inspection methods currently exist to detect the condition of the CIC and primer or corrosion and cracks in the truck beam, the Safety Board believes that the FAA should develop and require the periodic use of visual and NDI techniques to evaluate the condition of CIC and primer and to detect corrosion and cracks on the inner surface of the 757 MLG truck beam.

Boeing has not yet completed its analysis of samples of the CIC and primer from the Canada 3000 incident airplane MLG truck beam to determine the reasons for reduction in its corrosion protection capabilities. It is important that the FAA monitor the progress of that analysis and take appropriate actions accordingly. Therefore, the Safety Board believes that the FAA should monitor Boeing's testing and analysis of the Canada 3000 MLG truck beam CIC and primer and, after the reasons for the reduction in its corrosion protection capabilities are determined, take corrective action to ensure that 757 MLG truck beams have adequate corrosion protection.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require operators of Boeing 757s to conduct periodic inspections of the main landing gear truck beam to ensure that the drainage opening at the aft end of the beam is unobstructed. (A-98-62)
>
> Develop and require the periodic use of visual and nondestructive inspection techniques to evaluate the condition of corrosion inhibiting compound and primer and to detect corrosion and cracks on the inner surface of the Boeing 757 main landing gear truck beam. (A-98-63)
>
> Monitor the Boeing Commercial Airplane Group's testing and analysis of the Canada 3000 main landing gear truck beam corrosion inhibiting compound and primer and, after the reasons for the reduction in its corrosion protection capabilities are determined, take corrective action to ensure that Boeing 757 main landing gear truck beams have adequate corrosion protection. (A-98-64)

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[2] See Safety Board recommendations A-95-101 and -102, issued on October 27, 1995, which addressed a Boeing 767 right MLG trunnion failure in Hamburg, Germany.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 23, 1998

In reply refer to: M-98-103 through -116

Admiral James M. Loy
Commandant
U.S. Coast Guard
2100 2nd Street, S.W.
Washington, D.C. 20593-0001

On Friday afternoon, January 19, 1996, the U.S. tug *Scandia* had an engineroom fire while towing the unmanned U.S. tank barge *North Cape*, 4.5 miles off Point Judith, Rhode Island. All six crewmembers abandoned the *Scandia* amid 10-foot waves and 25-knots winds; however, no one was injured. The crew was unsuccessful in its attempts to release the anchor of the barge, which ran aground and spilled 828,000 gallons of home heating oil, causing the largest pollution incident in Rhode Island's history, an incident that led to the closing of local fisheries.[1] (The Eklof Marine Corporation, or EMC, was the company that operated the vessels.)

The National Transportation Safety Board determines that the probable cause of the fire damage aboard the tug *Scandia* and the subsequent grounding of and pollution from the barge *North Cape* was the EMC's inadequate oversight of maintenance and operations aboard those vessels, which permitted a fire of unknown origin to become catastrophic and eliminated any realistic possibility of arresting the subsequent drift and grounding of the barge. Contributing to the accident was the lack of adequate U.S. Coast Guard and industry standards addressing towing vessel safety.

After reviewing the *Scandia*'s discrepancy reports, interviewing EMC operations department personnel responsible for the oversight of vessel maintenance, and evaluating the implementation of the EMC's vessel inspection program (VIP), the Safety Board determined that the EMC's management oversight of vessel maintenance was poor, which resulted in reducing the safety of its vessels.

The International Maritime Organization adopted the International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) in 1993. The

[1]For more information, read Marine Accident Report—*Fire Aboard the Tug* Scandia *and the Subsequent Grounding of the Tug and the Tankbarge* North Cape *on Moonstone Beach, South Kingston, Rhode Island, on January 19, 1996* (NTSB/MAR-98/03).

ISM Code provides important guidance to shipping companies for exercising oversight of the operation and maintenance of oil tankers in international trade. However, no comparable guidance applies to tug-barges involved in domestic oil transportation. Therefore, the Safety Board believes that the Coast Guard and the American Waterways Operators, Inc., (AWO) should cooperate to develop and implement an effective safety management code to ensure adequate management oversight of the maintenance and operation of vessels involved in oil transportation by barges.

The Safety Board analyzed the captain's vessel operations in light of the predicted weather and the actual on-scene weather and found that although a winter storm was rapidly approaching, the captain continued to proceed into the open seas of the "Race," thus reducing his margin of safety for avoiding the storm. (After leaving Long Island Sound, vessels proceed through the Race, which serves as a gateway to the next sound--Block Island Sound. Vessels are exposed to high southerly winds, waves, and ocean swells while in the Race because it does not have any islands to provide protective land cover.) Further, the captain did not reassess his decision to continue his voyage beyond the sheltered waters of Long Island Sound to the Race, and neither he nor the EMC had any plan to consider alternatives in case the vessel was endangered by the storm.

The weather also played a key role in the grounding of and pollution from the *North Cape*. (After the Coast Guard had rescued the *Scandia*'s crewmembers and taken them to the station, the Coast Guard coxswain and some of the *Scandia*'s crewmembers returned to the *North Cape* to try to release its anchor.) The crewmen who boarded the barge to release its anchor discovered that the waves had increased to between 20 and 30 feet and were washing over the barge, making it impossible to release the anchor without risking severe injury. Had the weather not turned so severe, they may have been able to release the anchor.

The Safety Board's investigation shows that the EMC had no procedures that would enable the crew to assess weather-related voyage risks or require the captain to obtain updated weather information or require the captain to consult the EMC's shoreside management about the risk of continuing the voyage under the prevailing weather conditions.

Although the EMC left all weather-related decisions entirely to the captain, the Safety Board points out that current maritime safety management practices, such as those embodied in the ISM Code, emphasize that responsibility for vessel safety cannot be limited to ship captains but must be shared by the upper levels of the company's shoreside management. Therefore, the Safety Board believes that the Coast Guard should require towing vessel companies to develop and implement procedures whereby management officials communicate with ship captains at sea in times of potential or actual emergencies and during safety-critical periods of a voyage.

In response to the Coast Guard Authorization Act of 1996, the Coast Guard issued a notice of proposed rulemaking (NPRM) in October 1997 to improve towing-vessel and tank barge safety in a variety of areas. The Coast Guard's NPRM solicited public comments on voyage planning, and the Safety Board's recommendations, based on the findings of this accident investigation, are particularly relevant to the Coast Guard's request. They highlight the importance of voyage planning to the safety of tug-barge operations.

The *Scandia* accident shows that EMC's inadequate oversight of vessel operations resulted in the *Scandia*'s lack of preparedness to encounter the predicted bad weather and contributed to the accident. For example, if the EMC had had a checklist to ensure that the loose equipment and material aboard the *Scandia* were secured in heavy weather, to ensure that flammable materials were not stored in the engineroom, and to ensure that the *North Cape* was adequately equipped for the anticipated weather, the crew might have thought through the process of preparing for heavy weather and taking the necessary precautions, thus significantly improving the safety of operations.

The Safety Board, therefore, concludes that because the EMC did not have adequate voyage planning procedures to ensure that adequate weather information and operational precautions were considered in its decisionmaking, the risk reduction measures that could have been taken before the voyage began were not taken. Therefore, the Safety Board believes that the Coast Guard, in conjunction with the towing vessel industry, should develop and implement requirements for voyage planning standards and checklists for towing vessel companies to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of operational precautions.

In its NPRM, the Coast Guard proposed the use of an emergency barge retrieval system as an acceptable method by which a tug can recover its barge if the towline breaks. If the towline between a tug and its barge breaks, the tug can use an emergency barge retrieval system to retrieve its barge, but only if the tug, itself, is operational. In this accident, however, even if the *Scandia* had had a retrieval system, the vessel could not have used the system because the vessel was completely disabled by the fire. The same consequence would also result if a tug were to suffer other casualties, such as flooding, sinking, capsizing in heavy seas, or grounding. In such situations, a tug that has a retrieval system and is dispatched from another location is needed to retrieve the drifting barge.

While a number of tugs set out to assist the *North Cape* and were prevented by the weather from arriving on scene in time, the tugs were not strategically located when they started their journey to assist and were selected by chance. No organized system ensured that the tugs were strategically located so they could reach the accident scene in time or that the tugs were powerful enough or possessed the proper equipment to provide the assistance necessary. There was also no assurance that their crewmembers were trained to handle emergency retrieval operations without seriously endangering themselves and their tugs. A tug of opportunity system or an alternative system, therefore, may be necessary to complement the proposed retrieval system. (A tug of opportunity system is an organized system for diverting a tug, which may be towing or escorting another vessel or idling, to arrest a drifting oil barge or vessel. Under this system, information regarding the capabilities and locations of suitable tugs is monitored so that in an emergency the proper resources can be immediately dispatched to help. In addition, the system ensures that the tug is appropriate for the condition of the sea and for the size of the vessel to be helped.)

In this accident there was a 4 ½-hour period, from the start of the fire to the grounding of the barge, within which the barge could have been retrieved. The Safety Board concludes that the use of a tug assistance system in conjunction with a barge retrieval system would have significantly improved the chance of arresting the drift of the *North Cape* and preventing its grounding. Therefore, the Safety Board believes that the Coast Guard and the towing industry should institute a pilot project in the northeastern United States to evaluate the benefits of using an organized tug-assistance system to complement the proposed barge retrieval system or, if appropriate, develop and implement an alternative system to ensure barge retrieval if a tug becomes incapable of performing that function.

The *North Cape* had a 6,000-pound bow anchor. On the day of the accident, it was temporarily held in place on the bow anchor sled by a wire rope sling and shackle attached to an A-frame just behind the sled. The temporary arrangement was used while the windlass and its brake--which normally secured the anchor--were being repaired ashore. An appropriately designed and installed anchoring system may have reduced the possibility of grounding and pollution.

The captain had probably long been aware of the oncoming storm and could have chosen to wait out the storm by dropping anchor in a harbor of safe refuge in Long Island Sound. However, the lack of a windlass would have deterred him because there is no easy way to retrieve an anchor without a windlass, and he would have lost the anchor--a valuable piece of equipment. This fact may explain why the captain never considered this option.

It is difficult to say with certainty whether the drifting *North Cape* could have been completely stopped before running aground even if the anchor and windlass had been properly installed and operable. The ability of an anchor to stop a vessel depends on various unknown factors, such as the holding power of the sea bottom compared to the magnitude of the drag forces exerted on the barge by the seas and wind. While an anchor is often ineffective in stopping a self-propelled vessel within a limited distance when the vessel is traveling at speed, the *North Cape* was drifting slowly, and there was a considerable distance for the anchor to take hold on the bottom before the barge grounded. Having an anchor drag along the bottom would have slowed the barge down and may have stopped it before it reached shore, thus giving the assist tugs much more time to reach it. The Safety Board therefore concludes that an operable anchor may have reduced the chance of the barge grounding.

Anchors are routinely used to hold (to "anchor") a vessel in a waterway and are safety devices. Just as Coast Guard regulations require anchors on manned barges to enhance their safety, so would anchors increase the safety of unmanned barges. The Coast Guard, however, does not require an unmanned barge to have an anchor because the Coast Guard recognizes that normally there is no one on an unmanned barge to release the anchor.

Nevertheless, the *North Cape* was not unique in having an anchor and windlass because many owners equip their unmanned barges with an anchor and windlass for operational convenience. On such a barge, a crewman jumps from the tug to the barge. While the jump is usually safe under routine conditions, in rough seas or unfavorable conditions, the probability of injuries and deaths can be unacceptably high. In this accident, the lives of two tug crewmen were seriously endangered by the turbulent seas when they jumped aboard the *North Cape* to release the anchor. Even if the anchor and windlass had been properly installed, the Safety Board would have considered the risk to the crewmen's lives to be just as excessive. The Board's determination is supported by Coast Guard accident statistics, which show that slips and falls overboard are the largest cause of deaths and injuries in the towing industry.

The Safety Board thinks that such risk reduction strategies as remotely operated quick releases for barge anchors should be considered as a way of avoiding the risks associated with transferring people to an unmanned barge. The Safety Board concludes that when a tug is disabled, modern devices, such as radio-frequency transmitters, that are suitably located on the tug may be effective in releasing the barge's anchor by remote control and that the use of such transmitters does not involve imposing risks on the crew. A remotely operated mechanism can be designed to operate independently of the tug's primary power systems so that the device is not dependent on the tug's ability to propel or steer itself. A remote device can be activated quickly even if a tug has lost propulsion or steering, is involved in a fire, or is sinking.

In its NPRM, the Coast Guard invited readers to propose technological solutions to the problem of arresting drifting barges that are better than the existing techniques, which are often hazardous to the crews. The Safety Board, therefore, believes that the Coast Guard, in conjunction with the towing vessel industry, should develop modern remote anchor release devices for barges in emergencies that do not expose crewmen to unnecessary risk, and require their utilization. Further, the Safety Board believes that the AWO should encourage its members to work with the Coast Guard to develop a means of releasing anchors on unmanned towed barges by remote control from the towing vessel.

The safety of the Nation's fleet, about 30,000 barges, and its personnel and cargo, as well as the safety of the marine environment, depends to a large extent on the fire safety of the vessels that tow the barges. The fact has been consistently demonstrated by accident statistics for towing vessels, which show that fires are the second largest cause of towing vessel accidents. The statistics also show that almost all fires occur in the engineroom, where ignition sources, such as hot operating machinery and electrical equipment, are close to flammable fuels and oils and to the combustible materials used in the vessel's construction. The *Scandia* fire demonstrates how rapidly a fire on a tug can get out of control and cause a second accident involving a barge in its tow. The second accident caused large-scale pollution that significantly damaged the environment and drew public attention to this accident. The Safety Board determines that the chances of preventing pollution from towed oil barges would be greatly enhanced if Coast Guard regulations adequately addressed the fire safety of towing vessels.

Despite the fact that the *Scandia* had firefighting equipment, such as the semi-portable fire extinguishing system and the fire pump, that exceeded the Coast Guard requirements, the crew could not reach the equipment during the emergency. The intensity of the smoke and heat prevented the crewmembers from entering the fidley, and they could not reach the controls for the semi-portable extinguisher, which were only a few feet inside the fidley door. Consequently, the equipment was ineffective in fighting the fire.

To use the semi-portable system, crewmembers would have had to enter the fidley and move close to the fire so that they could manually unreel the hose and direct its nozzle toward the base of the fire. To enter the fidley, however, the crew would have had to wear firemen's outfits and self-contained breathing apparatus (SCBA). Firemen's outfits and SCBAs would also have significantly increased the effectiveness of the portable extinguishers, as the crewmen would have been able to get the extinguishers closer to the fire.

The Safety Board concludes that the *Scandia* accident demonstrates the need for SCBAs and firesuits on towing vessels. Therefore, the Safety Board believes that the Coast Guard should require SCBAs and firesuits aboard all towing vessels, as well as training in their use.

The crew would have been safer if the *Scandia* had had a fixed firefighting system in the engineroom that could be remotely operated from outside the engineroom. Crewmembers would not have been subject to the physical risks involved in entering a fire- and smoke-filled fidley, and the firefighting would have been more effective.

The Safety Board supports the NPRM in proposing the requiring of fixed fire extinguishing systems in the enginerooms of new tugs but notes that the NPRM does not require fixed fire extinguishing systems aboard existing tugs. Also, the NPRM would not require tugs such as the *Scandia* to have firefighting equipment beyond what is already aboard the vessel, which the crew could not operate in this accident because the equipment controls were located in areas made inaccessible by the fire. The Safety Board concludes that the NPRM proposes a lower level of safety for existing tugs than for new tugs and would not make existing tugs any safer from the kind of fire that the *Scandia* experienced in this accident. The Safety Board, therefore, believes that the Coast Guard should require approved fixed firefighting systems in the enginerooms of existing towing vessels.

Although the *Scandia* had a fire pump, it could only be operated from the lower engineroom. The crewmembers could not reach the lower engineroom because they could not even enter the smoke-filled fidley. (They needed to go down the stairway in the fidley to the lower engineroom, engage the clutch, and start the pump.) The Safety Board concludes that because the *Scandia*'s fire pump could not be started from outside the engineroom, it could not be used for fighting this fire. Therefore, the Safety Board believes that the Coast Guard should implement the requirement in its NPRM that fire pumps on towing vessels also be operable from outside the engineroom.

Neither the chief engineer, who led the firefighting, nor any other crewman was aware that the emergency remote shut-offs for the engineroom ventilation fans were just outside the fidley's aft door. The fans continued to supply the fire with fresh air, causing the fire to grow and spread rapidly. None of the crewmen activated the remote fuel pump or fuel valve shut-offs to the engineroom, which were also outside the aft door of the fidley.

Basic marine firefighting requires that all ventilation and fuel supply to the engineroom be shut off in the event of an engineroom fire. Although the chief engineer had completed a Coast-Guard-approved basic firefighting course, his statements to Safety Board investigators and his actions during the emergency show that he was not familiar with the location of the *Scandia*'s emergency shut-offs.

Although the crewmembers told Safety Board investigators that they had participated in emergency drills, they showed a lack of familiarity with the *Scandia*'s emergency firefighting systems. None of the crew had participated in engineroom firefighting drills on the *Scandia*, and none had been assigned specific duties in the event of a fire emergency. The chief engineer was the only crewman who said he knew how to operate the *Scandia*'s fire pump.

The Safety Board supports the proposals in the NPRM about requiring muster lists, drills on using SCBAs and fireman's outfits, and safety orientations that will familiarize crewmembers with their vessel before they sail. The Safety Board believes that the Coast Guard should incorporate these proposals in its regulations.

The Safety Board notes that it will be up to the vessel owners to comply with the regulations and that, for uninspected vessels, the Coast Guard intends to rely on spot checks rather than on an inspection program. Therefore, the Safety Board believes that the Coast Guard should require vessel owners to keep detailed, signed logs of all on-board drills to assist the Coast Guard in its spot checks.

Because oil spill statistics from 1992 to 1996 show that oil barges spilled eight times more oil than tank ships, the Safety Board questions whether the Coast Guard's safety regulations for tug-barge systems are adequate when compared to those for tank vessels. A comparison of some of the fire safety regulations that are relevant to the *Scandia* accident shows that tank ships are subject to significantly higher safety regulations than tug-barge systems, although both carry similar cargoes. Regulatory differences in fire safety, as well as in other areas, such as vessel inspection and equipment redundancies, may explain why the pollution from tug-barges is so much greater than that from tank ships.

If risks for tug-barge systems and tankers had been assessed with equal rigor, then the resulting regulations would probably have been comparable and would have provided an equivalent level of safety against pollution. Even though a regional risk assessment team conducted a risk assessment, based on which the Coast Guard issued the NPRM for improving tug-barge safety, the Board's investigation of this accident uncovered significant issues that were not addressed by the NPRM; thus, the proposed regulations may not be effective in reducing pollution. Even if the NPRM were adopted, it would not significantly reduce the overall regulatory discrepancy between tank vessels and tug-barges in many areas of safety, because the NPRM focuses only on safety issues relating to the *Scandia* accident. The Safety Board concludes that the large difference in the oil pollution data for the two vessel types quite likely results from the discrepancy in risk mitigation regulations that apply to them.

The Coast Guard has both the authority and the responsibility to direct a comprehensive risk assessment to mitigate the effects of marine accidents on the public and the environment. The Safety Board therefore believes that the Coast Guard should conduct a comprehensive risk assessment to develop risk mitigation regulations for tug-barge systems that provide a level of safety against marine pollution equivalent to that provided by regulations for tankers.

The Coast Guard rescue boat crew left the station in a 41-foot UTB. As a result, the crew lost 20 minutes in reaching the accident scene because the sea was unsafe for the UTB, forcing the SAR crew to return for a 44-foot MLB.

The delay did not prevent the Coast Guard from rescuing the *Scandia*'s crew. However, the delay allowed the fire to progress and caused a more dangerous situation to develop for the crewmembers while they waited for the Coast Guard to arrive. The delay also forced the SAR crew to conduct a more difficult in-the-water rescue because the wheelhouse windows on the tug had "exploded" by then, forcing the tug crew to enter the water. If the SAR crew had initially deployed in the MLB, the crew would have arrived 20 minutes sooner than it did, and the coxswain would been able to conduct a direct vessel-to-vessel transfer of the tug crew as he had earlier envisioned. As a result of the rescue, the rescue swimmer became hypothermic and the MLB returned to the station to get him medical treatment. The coxswain later returned to the barge with some of the tug crewmembers who boarded the barge and tried to drop its anchor. With an out-of-the-water transfer, the swimmer would not have suffered from hypothermia, and the crew of the *Scandia* would have been exposed to less risk. The sea would not have been as dangerous as it was when the tug crewmembers eventually did board the barge. The sea had become so dangerous that the coxswain was unable to retrieve one of the tug crewmen from the barge. Consequently helicopter crewmembers had to risk their lives to rescue the tug crewman stranded on the barge.

The coxswain explained that he initially selected the UTB instead of the MLB because the UTB was significantly faster and more maneuverable and offered greater protection from the weather. The coxswain's points are valid, but he did not recognize that the wind and sea were too severe for a UTB until he was some distance out to sea.

The coxswain made the decision to use a UTB instead of an MLB. According to the Coast Guard's SAR plan, the selection of the boat is the responsibility of the officer-in-charge (OIC) at the boat station. Because the OIC was not present at the time of the accident, it became the officer-on-duty's (OD's) responsibility. However, the OD did not give the coxswain any guidance about the type of boat to use.

Although the coxswain had seen a weather report posted at the station earlier that morning, he did not check a more recent weather report at the station. Instead, he based his knowledge of the weather on what he could readily see from the station windows. When the coxswain launched, the duty watchstander did not supply the latest weather update.

In the Safety Board's opinion, the Coast Guard's procedures for deploying the proper boat were adequate. However, the Coast Guard station personnel did not adequately follow the procedures. For instance, the OD did not give the coxswain the necessary guidance for selecting the boat, and the coxswain failed to check the latest weather information.

The Safety Board concludes that the OD and the coxswain did not consider the weather and sea conditions sufficiently in selecting the rescue boat, and the result was a 20-minute delay in arriving on scene. The Safety Board believes that Coast Guard stations should conduct a mandatory pre-deployment briefing for all SAR missions to ensure that the on-scene weather and sea conditions are assessed accurately so that the proper rescue boat is selected.

Coast Guard procedures prescribing the use of hypothermia protective clothing specify that in cold-water areas, a surface swimmer should don either a wet suit or a dry suit and a safety harness en route to the scene of the accident if the coxswain or boat crew has prior knowledge that someone must be rescued from the water. The coxswain is responsible for selecting the swimmer from the boat crew. During the initial response to the *Scandia*, the coxswain did not tell the swimmer to outfit himself because the coxswain did not anticipate that a rescue from the water would be necessary. As a result, when the swimmer entered the water, he was wearing only anti-exposure coveralls, which were inadequate to protect him from hypothermia.

In the Safety Board's opinion, it is likely that someone, either a Coast Guardsman or a civilian, will fall into the water during any small-boat rescue operation in rough seas. Therefore, the need for a swimmer to enter the water should always be anticipated under such conditions. Since it is extremely difficult to remove anti-exposure coveralls and don a dry or wet suit on a rolling and pitching small boat in rough seas, a pre-designated swimmer should don appropriate thermal protective garments before the boat leaves the station in cold-water areas. The Safety Board concludes that had the swimmer been properly attired, he probably would not have become hypothermic. The Safety Board, therefore, believes that the Coast Guard should establish and implement procedures to require a pre-designated swimmer to don suitable thermal protective clothing before launching a small boat on a SAR mission in cold water.

The Safety Board analyzed the group commander's decision to send a Coast Guard crew, along with two *Scandia* crewmen, to the *North Cape* to drop its anchor. This decision required an analysis of the potential risks of injury or death to the Coast Guard and civilian personnel, an assessment of the risk of loss of or damage to Coast Guard resources, and a judgment about the probability of success. Of particular concern to the Board was the group commander's decision to place civilian lives at risk to conduct this dangerous mission. The Safety Board concludes that although the coxswain, the Coast Guard boat crew, and the tug crew volunteers made an heroic attempt to prevent an oil spill, the decision to allow them to do so was ill-conceived and not justified.

The Coast Guard Air Station Cape Cod had informed the group commander that the air station would not provide a helicopter to deliver anyone to the barge because aviation risk assessment criteria specify that SAR personnel should only be placed at risk if human lives are in danger. When the group commander proceeded with the salvage mission, he did not tell the air station.

While the group commander thought he had assessed the risks fully before he ordered the attempt to drop the barge anchor, in the Safety Board's view he had not. He did not fully recognize the severity of the sea and weather conditions or anticipate that another life-threatening rescue would be necessitated as a result of the dangers encountered by the salvage crew. Such an assessment has been identified in previous Safety Board investigations.

As a result of its investigation of the 1991 capsizing and sinking of the U.S. commercial fishing vessel *Sea King*,[2] the Safety Board issued Safety Recommendation M-92-54 to the Coast Guard:

> Incorporate into the training of SAR personnel procedures to ensure the gathering and dissemination of pertinent information by all appropriate SAR personnel to facilitate a thorough assessment of the potential risks to persons involved in a SAR mission.

As the result of the investigation of three 1993 accidents[3] involving Coast Guard SAR responses that proved unsuccessful because of the inadequacy of the risk assessments, the Safety Board issued Safety Recommendation M-94-7 to the Coast Guard:

> Provide risk assessment training to all Coast Guard personnel directly involved in SAR missions.

On November 21, 1994, the Coast Guard Commandant stated:

> I concur with these recommendations. The Coast Guard has taken action to add risk assessment training for SAR personnel at appropriate levels in the operational chain of command, and full implementation is expected by May of 1995.

The Commandant's response further indicated that, as a result of the Board's recommendations, risk assessment training had been included in training courses for small-boat coxswains, for pilots and aircrews, for small-boat station commanders, for cutter commanders and executive officers, for operations-center watchstanders, and for group and station commanding officers and executive officers. As a result of the Commandant's response, Safety Recommendations M-92-54 and M-94-7 were classified "Closed--Acceptable Action."

While the Safety Board is gratified that the Coast Guard has incorporated risk assessment training in the training for all levels of SAR activity, from small-boat coxswain to group commander, training in and of itself does not ensure that proper risk assessments will be made in all cases. To be truly effective, training must be reinforced by pertinent operational guidelines. According to the pilot of a rescue helicopter, the operations officer at the air station declined to provide helicopter assistance for the salvage mission after consulting personnel from the Group. The request was denied because the formal risk assessment guidelines, which are in the Coast Guard Commandant's Instruction 3710, *Air Operations Manual*, prohibit the placing of a Coast Guard helicopter and air crew at grave risk for any operation, such as a salvage mission, that is

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[2]For more information, read Marine Accident Report -- *Capsizing and Sinking of the U.S. Fishing Vessel* Sea King *Near Astoria, Oregon, January 11, 1991* (NTSB/MAR-92/05).

[3]For more information, read Marine Accident Brief Reports--*Grounding of the U.S. Sailing Pleasure Craft* Rite of Passage*, Isle of Palms, South Carolina, August 4, 1993* (DCA-93-MM-023); *Sinking of the U.S. Pleasure Craft* Big Abalone, *Coos Bay, Oregon, August 20, 1993* (DCA-93-MM-029); and *Sinking of the U.S. Tug* Duke Luedtke, *in Lake Erie, near Cleveland, Ohio, September 21, 1993* (DCA-93-MM-030).

not a life-threatening emergency. (The risk of losing the aircraft or the air crew is considered a grave risk.)

The group commander did not have any comparable published formal risk assessment guidelines to follow in making his assessment of the risks presented by the salvage operation. In the Board's opinion, it is just as necessary to provide guidelines for placing Coast Guard surface craft and surface personnel at "grave risk" as it is to provide such guidelines for aircraft and aviation personnel. The guidelines should clearly explain the procedures for conducting risk assessments and analyses that are necessary before conducting SAR and salvage missions, for identifying grave risk to surface craft and personnel, and for obtaining concurrence and approval from the respective district commands. In particular, the guidelines should emphasize the need to protect civilian lives from unnecessary "grave risks." The Safety Board concludes that developing and implementing risk assessment guidelines for the deployment of surface SAR units that are similar to those for the deployment of aircraft would enhance the quality of risk assessments by Coast Guard operational commanders. The Safety Board, therefore, believes that the Coast Guard should develop and implement risk assessment guidelines for the deployment of surface SAR units that are similar to those published in Coast Guard Commandant's Instruction 3710.

As a result of its investigation of this accident, the National Transportation Safety Board makes the following safety recommendations to the U.S. Coast Guard:

> Conduct a comprehensive risk assessment to develop risk mitigation regulations for tug-barge systems that provide a level of safety against marine pollution equivalent to that provided by regulations for tankers. (M-98-103)
>
> In conjunction with the towing vessel industry, develop and implement an effective safety management code to ensure adequate management oversight of the maintenance and operation of vessels involved in oil transportation by barges. (M-98-104)
>
> Require towing vessel companies to develop and implement procedures whereby management officials communicate with ship captains at sea in times of potential or actual emergencies and during safety-critical periods of a voyage. (M-98-105)
>
> In conjunction with the towing vessel industry, develop and implement requirements for voyage planning standards and checklists for towing vessel companies to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of operational precautions. (M-98-106)
>
> In conjunction with the towing vessel industry in the northeastern United States, institute a pilot project to evaluate the benefits of using an organized tug-assistance system to complement the proposed barge retrieval system or, if appropriate, develop and implement an alternative system to ensure barge retrieval if a tug becomes incapable of performing that function. (M-98-107)

In conjunction with the towing vessel industry, develop modern remote anchor release devices for barges in emergencies that do not expose crewmen to unnecessary risk, and require their utilization. (M-98-108)

Require self-contained breathing apparatus and firesuits aboard all towing vessels, as well as training in their use. (M-98-109)

Require approved fixed firefighting systems in the enginerooms of existing towing vessels. (M-98-110)

Require that fire pumps on towing vessels also be operable from outside the engineroom. (M-98-111)

Require that towing vessels have muster lists, drills on the use of self-contained breathing apparatus and fireman's outfits, and safety orientations to familiarize crewmembers with their vessel before sailing. (M-98-112)

Require vessel owners to keep detailed, signed logs of all on-board drills to assist the Coast Guard in its spot checks. (M-98-113)

Require Coast Guard station search and rescue personnel to conduct a mandatory pre-deployment briefing for all search and rescue missions to ensure that the on-scene weather and sea conditions are assessed accurately so that the proper rescue boat is selected. (M-98-114)

Establish and implement procedures to require a pre-designated swimmer to don suitable thermal protective clothing before launching in a small boat on a search and rescue mission in cold water. (M-98-115)

Develop and implement risk assessment guidelines for the deployment of surface search and rescue units similar to the guidelines published in Coast Guard Commandant's Instruction 3710. (M-98-116)

Also, the Safety Board issued Safety Recommendations M-98-117 through -119 to Eklof Marine Corporation and M-98-120 through -122 to the American Waterways Operators, Inc.

Please refer to Safety Recommendations M-98-103 through -116 in your reply. If you need additional information, you may call (202) 314-6450.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 23, 1998

In reply refer to: M-98-117 through -119

Mr. Douglas Eklof
President
Eklof Marine Corporation
3245 Richmond Terrace
Staten Island, New York 10303

On Friday afternoon, January 19, 1996, the U.S. tug *Scandia* had an engineroom fire while towing the unmanned U.S. tank barge *North Cape*, 4.5 miles off Point Judith, Rhode Island. All six crewmembers abandoned the *Scandia* amid 10-foot waves and 25-knot winds; however, no one was injured. The crew was unsuccessful in its attempts to release the anchor of the barge, which ran aground and spilled 828,000 gallons of home heating oil, causing the largest pollution incident in Rhode Island's history, an incident that led to the closing of local fisheries. [1]

The National Transportation Safety Board determines that the probable cause of the fire damage aboard the tug *Scandia* and the subsequent grounding of and pollution from the barge *North Cape* was the EMC's inadequate oversight of maintenance and operations aboard those vessels, which permitted a fire of unknown origin to become catastrophic and eliminated any realistic possibility of arresting the subsequent drift and grounding of the barge. Contributing to the accident was the lack of adequate U.S. Coast Guard and industry standards addressing towing vessel safety.

After reviewing the *Scandia*'s discrepancy reports, interviewing EMC operations department personnel responsible for the oversight of vessel maintenance, and evaluating the implementation of the EMC's vessel inspection program (VIP), the Safety Board determined that the EMC's management oversight of vessel maintenance was poor, which resulted in reducing the safety of its vessels.

The VIP formed the cornerstone of the EMC's program of having its management oversee vessel maintenance. However, the Safety Board found that although the EMC had a VIP on paper, the EMC did not implement the VIP in practice, as evidenced by the discrepancy

[1] For more information, read Marine Accident Report—*Fire Aboard the Tug* Scandia *and the Subsequent Grounding of the Tug and the Tankbarge* North Cape *on Moonstone Beach, South Kingston, Rhode Island, on January 19, 1996* (NTSB/MAR-98/03).

reports. Had the EMC followed its VIP, there would not have been the numerous instances of extended delays in repairing safety and maintenance items because the program required that serious safety deficiencies be repaired within about 2 weeks. Instead, safety and maintenance problems were not corrected for months, sometimes for more than a year.

Significant delays in making repairs, as evidenced by the crew's repeated complaints on their monthly discrepancy reports, demonstrate that the EMC's management did not oversee the maintenance process and did not have controls to ensure that repairs were done in a timely enough manner to comply with the EMC's own procedures.

Because the EMC, by policy, did not keep maintenance or repair records, the operations department did not have a database with which to track the *Scandia*'s history of repairs and maintenance. Without such a history, maintenance managers could not monitor trends in failure rates of the *Scandia*'s equipment and could not make informed decisions about the vessel's need for preventative maintenance. The result was poor maintenance of the *Scandia* and repeated complaints from its captains.

Not only did the absence of a planned maintenance program result in the *Scandia* being poorly maintained, the absence probably affected the maintenance of the entire EMC fleet. The EMC's process for exercising vessel maintenance (the VIP) was applied to all vessels in the EMC fleet and was enforced by the same personnel at the EMC.

The EMC's poor oversight of maintenance resulted in a reduction of the *Scandia*'s safety. Some of the discrepancies, such as missing safety guards, required relatively minor effort to fix; consequently, they should have been expeditiously repaired by vessel crewmen. By allowing the vessel's fire pump to corrode to the point of developing holes the size of a quarter, by permitting fire hoses with mismatched hose threads, and by sealing off emergency escape hatches, the EMC rendered these key safety features ineffective.

Because the engineroom smoke described in the discrepancy report for June 1995 was severe enough to have been seen by passing vessels, the smoke was likely to have discouraged the *Scandia*'s crewmembers from effectively monitoring the proper functioning of engineroom equipment during their engineroom tours. In addition to being an obvious safety hazard for the *Scandia*, the severe smoke also posed a health hazard for its crew.

The Safety Board, therefore, concludes that the EMC's oversight of vessel maintenance for its fleet was inadequate and that the implementation of its VIP was ineffective. The Safety Board believes that the EMC should develop and implement an effective management oversight program that provides maintenance managers with enough information to track maintenance trends and to make informed maintenance decisions that will ensure the safety of the company's fleet and crews.

The Safety Board analyzed the captain's vessel operations in light of the predicted weather and the actual on-scene weather and found that although a winter storm was rapidly approaching, the captain continued to proceed into the open seas of the Race, thus reducing his margin of safety for avoiding the storm. Further, the captain did not reassess his decision to continue his voyage beyond the sheltered waters of Long Island Sound to the Race, and neither he nor the EMC had any plan to consider alternatives in case the vessel was endangered by the storm.

This investigation shows that the EMC had no procedures that would enable the crew to assess weather-related voyage risks or require the captain to obtain updated weather information or require the captain to consult the EMC's shoreside management about the risk of continuing the voyage under the prevailing weather conditions.

The captain and the EMC's shoreside management did not consult about continuing the voyage from Long Island Sound into the Race. Had the EMC's management helped the captain to identify the risks, alternative courses of action could have resulted. An example of an alternative would have been the captain seeking safe harbor while the *Scandia* was sailing in the sheltered lee of Long Island Sound before proceeding into the exposed waters of the Race, where the vessel encountered rapidly worsening weather. The lack of an operable windlass may have deterred the captain from seeking shelter in the sound because once an anchor is dropped, it cannot be easily retrieved without a windlass. However, the need for a windlass in case the weather rapidly worsened should have been considered by the EMC through use of an equipment checklist as a part of voyage planning procedures.

Although the EMC left all weather-related decisions entirely to the captain, the Safety Board points out that current maritime safety management practices, such as those embodied in the International Safety Management Code, emphasize that responsibility for vessel safety cannot be limited to ship captains but must be shared by the upper levels of the company's shoreside management. Therefore, the Safety Board believes that the EMC should develop and implement procedures whereby designated management officials communicate with ship captains at sea in times of potential or actual emergencies and during safety-critical periods of a voyage. The procedures should be directed toward facilitating the making of timely decisions that affect the safety of company vessels and crews.

Voyage planning does more than improve the communications between a captain and his company's shoreside management; voyage planning can significantly improve a company's oversight of operations and its evaluation of weather-related risks, thereby reducing, at the planning stages of a voyage, the risk of an accident. The *Scandia* accident shows that EMC's inadequate oversight of vessel operations resulted in the *Scandia*'s lack of preparedness to encounter the predicted bad weather and contributed to the accident. For example, if the EMC had had a checklist to ensure that the loose equipment and material aboard the *Scandia* were secured in heavy weather, to ensure that flammable materials were not stored in the engineroom, and to ensure that the *North Cape* was adequately equipped for the anticipated weather, the crew might have thought through the process of preparing for heavy weather and taking the necessary precautions, thus significantly improving the safety of operations.

The Safety Board, therefore, concludes that because the EMC did not have adequate voyage planning procedures to ensure that adequate weather information and operational precautions were considered in its decisionmaking, the risk reduction measures that could have been taken before the voyage began were not taken. Consequently, the Safety Board believes that the EMC should develop and implement voyage planning procedures and checklists for its towing vessels to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of operational precautions.

Therefore, the National Transportation Safety Board issues the following safety recommendations to Eklof Marine Corporation:

> Develop and implement an effective management oversight program that provides maintenance managers with enough information to track maintenance trends and to make informed maintenance decisions that will ensure the safety of the company's fleet and crews. (M-98-117)
>
> Develop and implement procedures whereby designated management officials communicate with ship captains at sea in times of potential or actual emergencies and during safety-critical periods of a voyage. (M-98-118)
>
> Develop and implement voyage planning procedures and checklists for your towing vessels to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of operational precautions. (M-98-119)

Also, the Safety Board issued Safety Recommendations M-98-103 through -116 to the U.S. Coast Guard and M-98-120 through -122 to the American Waterways Operators, Inc.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations M-98-117 through -119 in your reply. If you need additional information, you may call (202) 314-6450.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 23, 1998

In reply refer to: M-98-120 through -122

Mr. Thomas A. Allegretti
President
American Waterways Operators, Inc.
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Arlington, Virginia 22209

On Friday afternoon, January 19, 1996, the U.S. tug *Scandia* had an engineroom fire while towing the unmanned U.S. tank barge *North Cape*, 4.5 miles off Point Judith, Rhode Island. All six crewmembers abandoned the *Scandia* amid 10-foot waves and 25-knot winds; however, no one was injured. The crew was unsuccessful in its attempts to release the anchor of the barge, which ran aground and spilled 828,000 gallons of home heating oil, causing the largest pollution incident in Rhode Island's history, an incident that led to the closing of local fisheries. [1] (The Eklof Marine Corporation, or EMC, was the company that operated the vessels.)

The National Transportation Safety Board determines that the probable cause of the fire damage aboard the tug *Scandia* and the subsequent grounding of and pollution from the barge *North Cape* was the EMC's inadequate oversight of maintenance and operations aboard those vessels, which permitted a fire of unknown origin to become catastrophic and eliminated any realistic possibility of arresting the subsequent drift and grounding of the barge. Contributing to the accident was the lack of adequate U.S. Coast Guard and industry standards addressing towing vessel safety.

After reviewing the *Scandia*'s discrepancy reports, interviewing EMC operations department personnel responsible for the oversight of vessel maintenance, and evaluating the implementation of the EMC's vessel inspection program, the Safety Board determined that the EMC's management oversight of vessel maintenance was poor, which resulted in reducing the safety of its vessels.

Significant delays in making repairs, as evidenced by the crew's repeated complaints on their monthly discrepancy reports, demonstrate that the EMC's management did not oversee the

[1]For more information, read Marine Accident Report—*Fire Aboard the Tug* Scandia *and the Subsequent Grounding of the Tug and the Tankbarge* North Cape *on Moonstone Beach, South Kingston, Rhode Island, on January 19, 1996* (NTSB/MAR-98/03).

maintenance process and did not have controls to ensure that repairs were done in a timely enough manner to comply with the EMC's own procedures.

Because the EMC, by policy, did not keep maintenance or repair records, the operations department did not have a database with which to track the *Scandia*'s history of repairs and maintenance. Without such a history, maintenance managers could not monitor trends in failure rates of the *Scandia*'s equipment and could not make informed decisions about the vessel's need for preventative maintenance. The result was poor maintenance of the *Scandia* and repeated complaints from its captains.

Not only did the absence of a planned maintenance program result in the *Scandia* being poorly maintained, the absence probably affected the maintenance of the entire EMC fleet. The EMC's process for exercising vessel maintenance was applied to all vessels in the EMC fleet and was enforced by the same personnel at the EMC.

The International Maritime Organization adopted the International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) in 1993. The ISM Code provides important guidance to shipping companies for exercising oversight of the operation and maintenance of oil tankers in international trade. However, no comparable guidance applies to tug-barges involved in domestic oil transportation. Therefore, the Safety Board believes that the Coast Guard and the AWO should cooperate to develop and implement an effective safety management code to ensure adequate management oversight of the maintenance and operation of vessels involved in oil transportation by barges.

The Safety Board analyzed the captain's vessel operations in light of the predicted weather and the actual on-scene weather and found that although a winter storm was rapidly approaching, the captain continued to proceed into the open seas of the "Race," thus reducing his margin of safety for avoiding the storm. (After leaving Long Island Sound, vessels proceed through the Race, which serves as a "gateway" to the next sound--Block Island Sound. Vessels are exposed to high southerly winds, waves, and ocean swells while in the Race because it does not have any islands to provide protective land cover.) Further, the captain did not reassess his decision to continue his voyage beyond the sheltered waters of Long Island Sound to the Race, and neither he nor the EMC had any plan to consider alternatives in case the vessel was endangered by the storm.

Despite the prediction of a sharp deterioration in the weather, the captain of the *Scandia* allowed himself only a narrow margin in which to avoid facing such weather in open seas; consequently, the Safety Board analyzed the EMC's operations to determine whether establishing voyage planning procedures could increase the safety of the operations of the EMC's vessels.

This investigation shows that the EMC had no procedures that would enable the crew to assess weather-related voyage risks or require the captain to obtain updated weather information or require the captain to consult the EMC's shoreside management about the risk of continuing the voyage under the prevailing weather conditions.

The captain and the EMC's shoreside management did not consult about continuing the voyage from Long Island Sound into the Race. Had the EMC's management helped the captain to identify the risks, alternative courses of action could have resulted. An example of an alternative would have been the captain seeking safe harbor while the *Scandia* was sailing in the sheltered lee of Long Island Sound before proceeding into the exposed waters of the Race, where the vessel encountered rapidly worsening weather.

Although the EMC left all weather-related decisions entirely to the captain, the Safety Board points out that current maritime safety management practices, such as those embodied in the ISM Code, emphasize that responsibility for vessel safety cannot be limited to ship captains but must be shared by the upper levels of the company's shoreside management. Therefore, the Safety Board believes that the EMC should develop and implement procedures whereby designated management officials communicate with ship captains at sea in times of potential or actual emergencies and during safety-critical periods of a voyage. The procedures should be directed toward facilitating the making of timely decisions that affect the safety of company vessels and crews. The Safety Board also believes that the Coast Guard should require towing vessel companies to develop and implement procedures whereby management officials communicate with ship captains at sea in times of potential or actual emergencies and during safety-critical periods of a voyage.

Voyage planning does more than improve the communications between a captain and his company's shoreside management; voyage planning can significantly improve a company's oversight of operations and its evaluation of weather-related risks, thereby reducing, at the planning stages of a voyage, the risk of an accident. The *Scandia* accident shows that EMC's inadequate oversight of vessel operations resulted in the *Scandia*'s lack of preparedness to encounter the predicted bad weather and contributed to the accident. For example, if the EMC had had a checklist to ensure that the loose equipment and material aboard the *Scandia* were secured in heavy weather, to ensure that flammable materials were not stored in the engineroom, and to ensure that the *North Cape* was adequately equipped for the anticipated weather, the crew might have thought through the process of preparing for heavy weather and taking the necessary precautions, thus significantly improving the safety of operations.

The Safety Board, therefore, concludes that because the EMC did not have adequate voyage planning procedures to ensure that adequate weather information and operational precautions were considered in its decisionmaking, the risk reduction measures that could have been taken before the voyage began were not taken. Consequently, the Safety Board believes that the EMC should develop and implement voyage planning procedures and checklists for its towing vessels to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of operational precautions. Further, the Safety Board believes that the Coast Guard, in conjunction with the towing vessel industry, should develop and implement requirements for voyage planning standards and checklists for towing vessel companies to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of operational precautions. Moreover, the AWO should encourage its member towing vessel companies to develop and implement such standards and checklists.

The *North Cape* had a 6,000-pound bow anchor. On the day of the accident, it was temporarily held in place on the bow anchor sled by a wire rope sling and shackle attached to an A-frame just behind the sled. The temporary arrangement was used while the windlass and its brake--which normally secured the anchor--were being repaired ashore. An appropriately designed and installed anchoring system may have reduced the possibility of grounding and pollution.

It is difficult to say with certainty whether the drifting *North Cape* could have been completely stopped before running aground even if the anchor and windlass had been properly installed and operable. The ability of an anchor to stop a vessel depends on various unknown factors, such as the holding power of the sea bottom compared to the magnitude of the drag forces exerted on the barge by the seas and wind. While an anchor is often ineffective in stopping a self-propelled vessel within a limited distance when the vessel is traveling at speed, the *North Cape* was drifting slowly, and there was a considerable distance for the anchor to take hold on the bottom before the barge grounded. Having an anchor drag along the bottom would have slowed the barge down and may have stopped it before it reached shore, thus giving the assist tugs much more time to reach it. The Safety Board therefore concludes that an operable anchor may have reduced the chance of the barge grounding.

Anchors are routinely used to hold (to "anchor") a vessel in a waterway and are safety devices. Just as Coast Guard regulations require anchors on manned barges to enhance their safety, so would anchors increase the safety of unmanned barges. The Coast Guard, however, does not require an unmanned barge to have an anchor because the Coast Guard recognizes that normally there is no one on an unmanned barge to release the anchor.

Nevertheless, the *North Cape* was not unique in having an anchor and windlass because many owners equip their unmanned barges with an anchor and windless for operational convenience. On such a barge, a crewman jumps from the tug to the barge. While the jump is usually safe under routine conditions, in rough seas or unfavorable conditions, the probability of injuries and deaths can be unacceptably high. In this accident, the lives of two tug crewmen were seriously endangered by the turbulent seas when they jumped aboard the *North Cape* to release the anchor. Even if the anchor and windlass had been properly installed, the Safety Board would have considered the risk to the crewmen's lives to be just as excessive. The Board's determination is supported by Coast Guard accident statistics, which show that slips and falls overboard are the largest cause of deaths and injuries in the towing industry.

The Safety Board believes that such risk reduction strategies as remotely operated quick releases for barge anchors should be considered as a way of avoiding the risks associated with transferring people to an unmanned barge. The Safety Board concludes that when a tug is disabled, modern devices, such as radio-frequency transmitters, that are suitably located on the tug may be effective in releasing the barge's anchor by remote control and that the use of such transmitters does not involve imposing risks on the crew. A remotely operated mechanism can be designed to operate independently of the tug's primary power systems so that the device is not dependent on the tug's ability to propel or steer itself. A remote device can be activated quickly even if a tug has lost propulsion or steering, is involved in a fire, or is sinking.

The Safety Board, therefore, believes that the Coast Guard, in conjunction with the towing vessel industry, should develop modern remote anchor release devices for barges in emergencies that do not expose crewmen to unnecessary risk, and require their utilization. Further, the Safety Board believes that the AWO should encourage its members to work with the Coast Guard to develop a means of releasing anchors on unmanned towed barges by remote control from the towing vessel.

Therefore, the National Transportation Safety Board issues the following safety recommendations to American Waterways Operators, Inc.:

> Develop an effective safety management code for your member companies to implement to ensure adequate management oversight of the maintenance and operation of vessels involved in oil transportation by barges. (M-98-120)
>
> Encourage your member towing vessel companies to develop and implement voyage planning standards and checklists to ensure that adequate risk reduction measures are taken before starting a voyage, including an assessment of weather risks, of the adequacy of the vessel's equipment, and of the operational precautions. (M-98-121)
>
> In cooperation with the Coast Guard, develop a means of releasing anchors on unmanned towed barges by remote control from the towing vessel. (M-98-122)

Also, the Safety Board issued Safety Recommendations M-98-103 through -116 to the U.S. Coast Guard and M-98-117 through -119 to Eklof Marine Corporation.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations M-98-120 through -122 in your reply. If you need additional information, you may call (202) 314-6450.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman